THE ENGINEER

SEPTEMBER 11, 1959 | 28 ESSEX STREET, STRAND, LONDON, W.C.2 | TWO SHILLINGS

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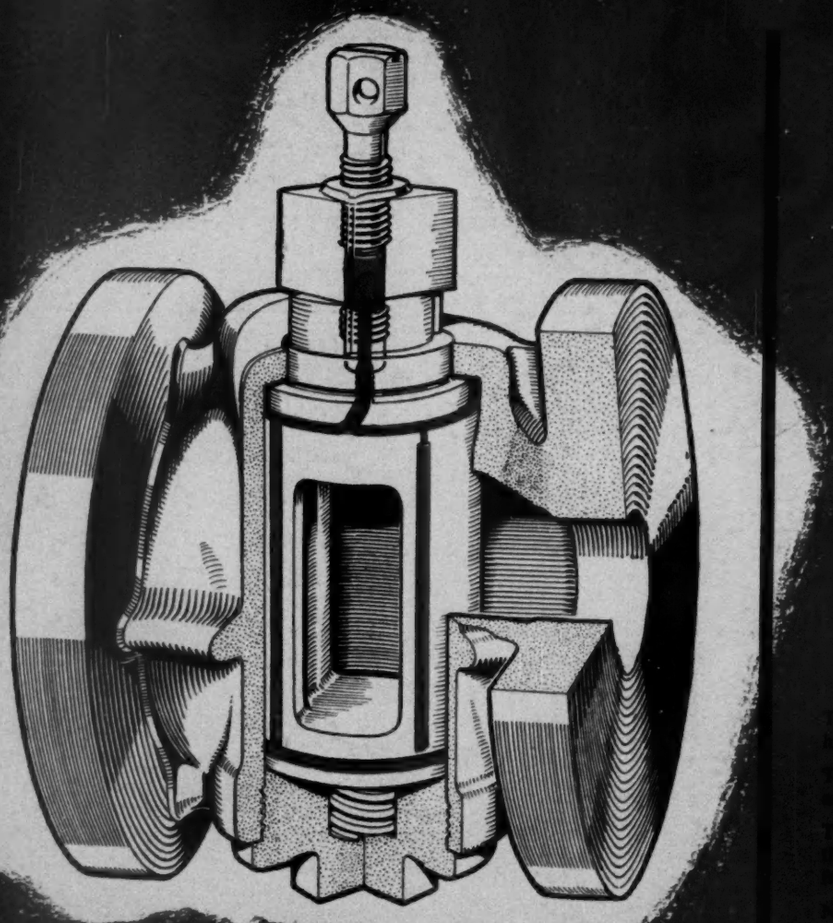

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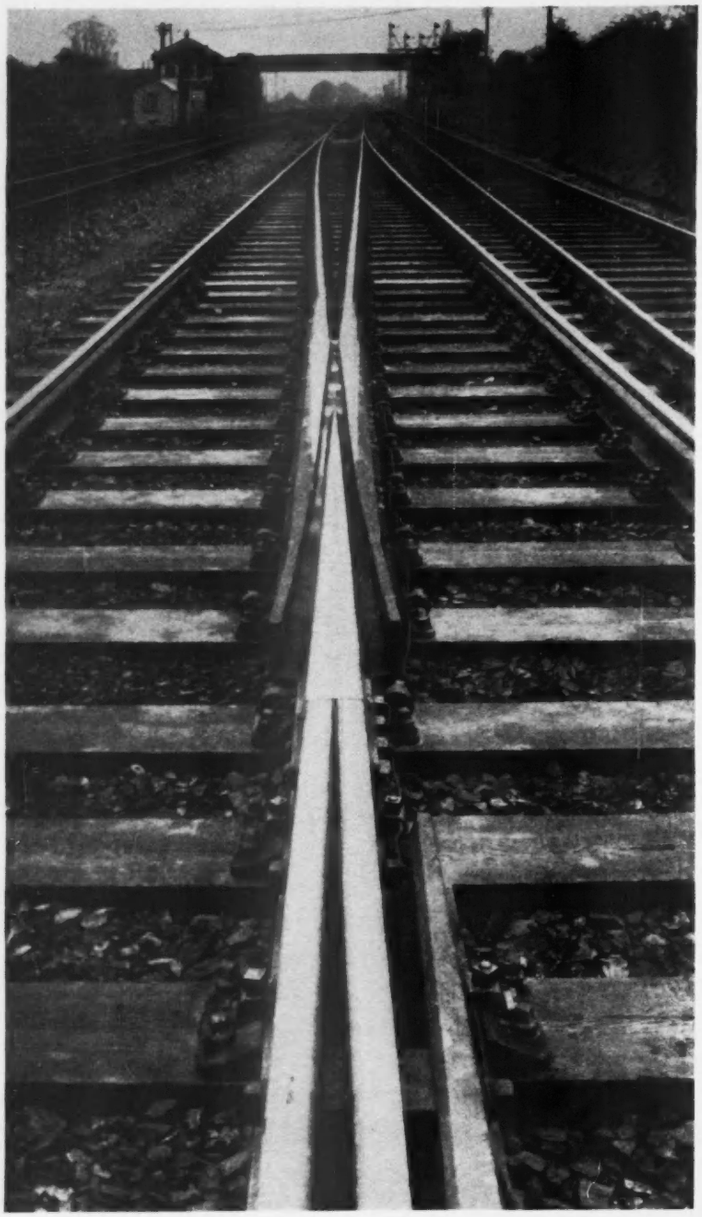

Photograph reproduced by courtesy of British Railways (Southern Region).

The accompanying illustration shows Solid Cast Monoblock Crossings of Hadfields Era High Manganese Steel, in site at Worthing Junction on the Southern Region of British Railways.

The Crossing angle 1 in 28, and approx. 25ft. long, represent a new departure in the application of the cast monoblock type of Crossing, and are designed to carry heavy main line traffic at high speeds.

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No. 5407 **SEPTEMBER 11, 1959** VOL. 208

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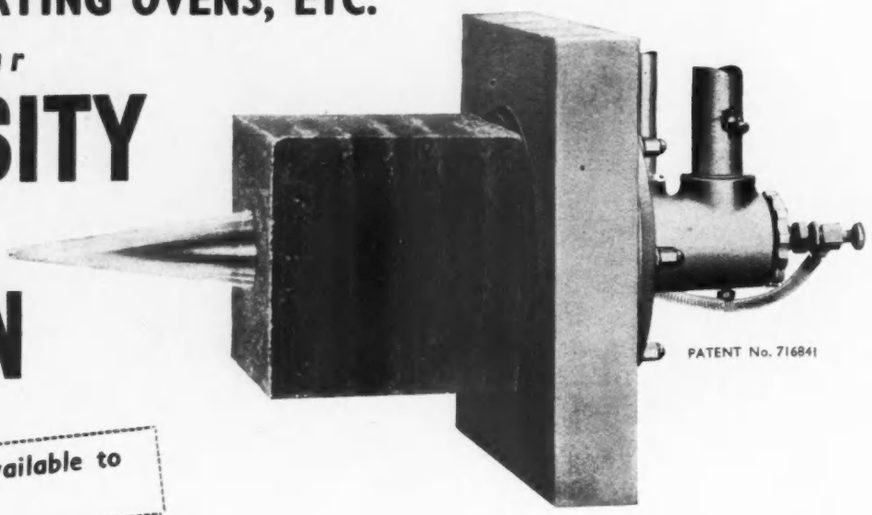

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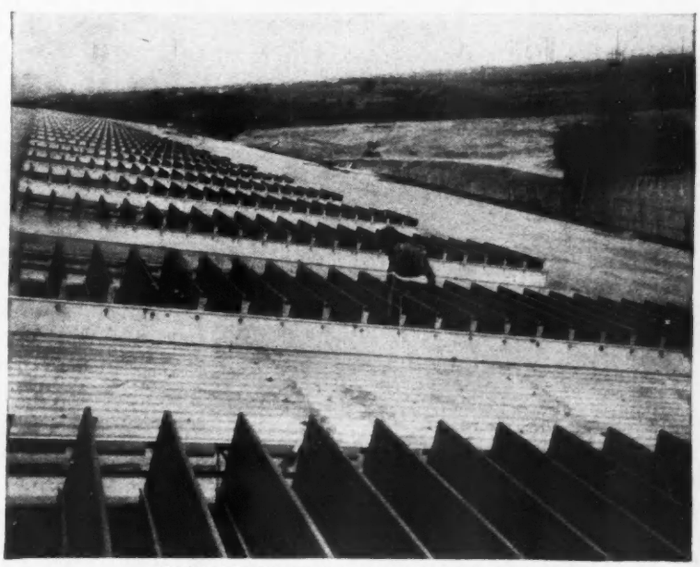

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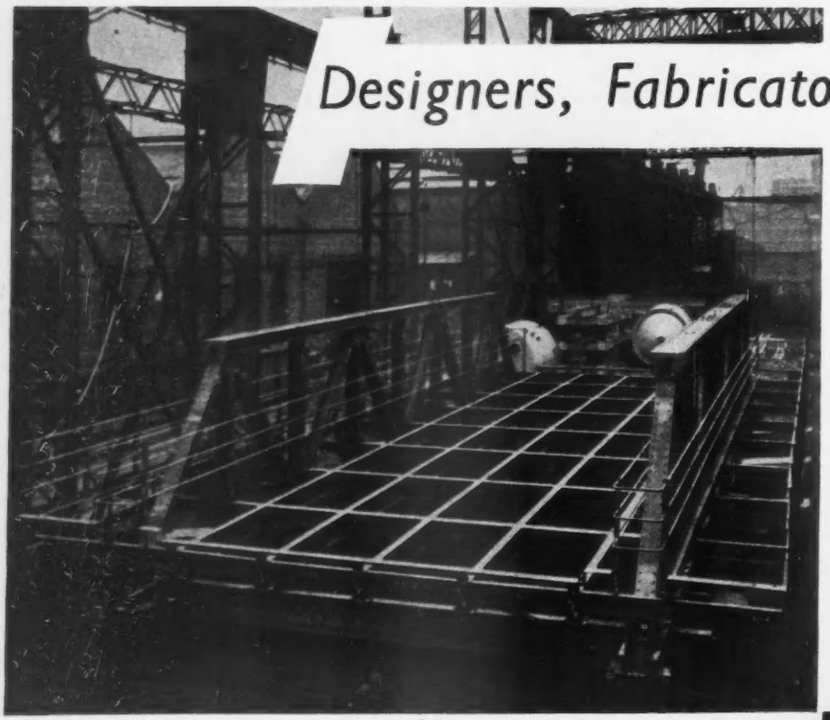

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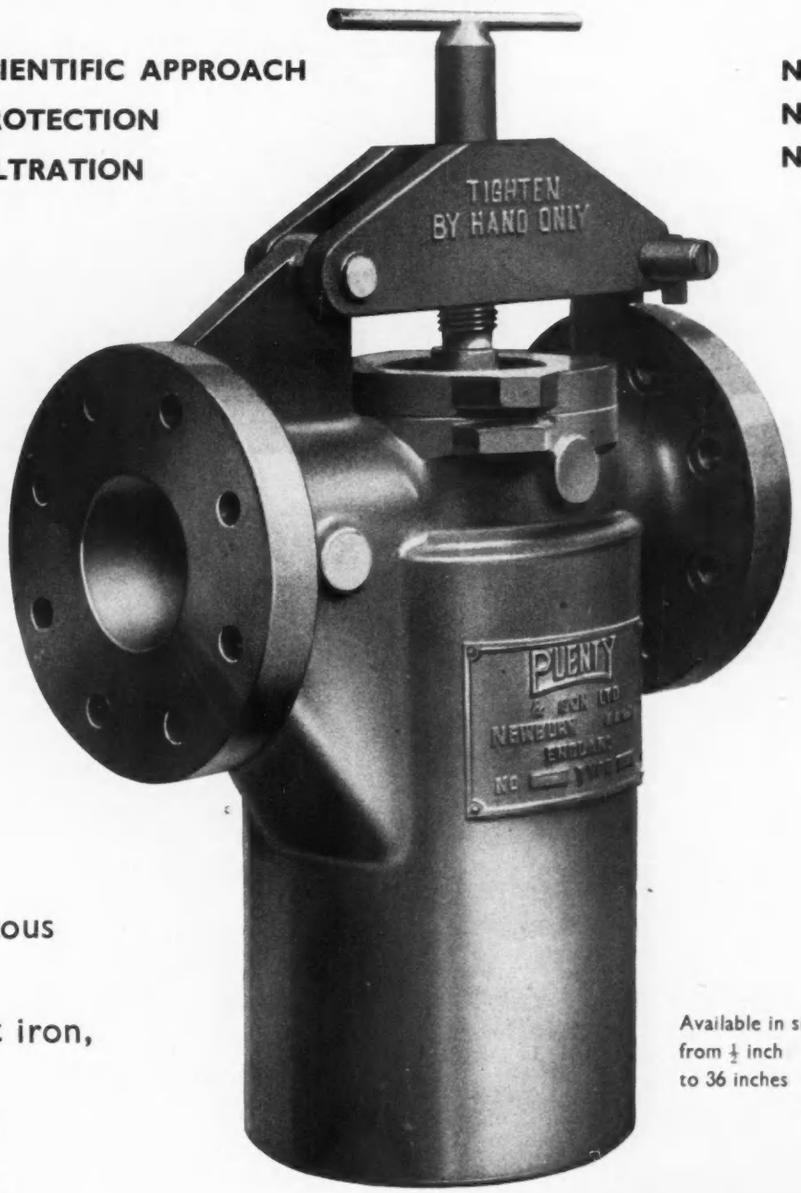

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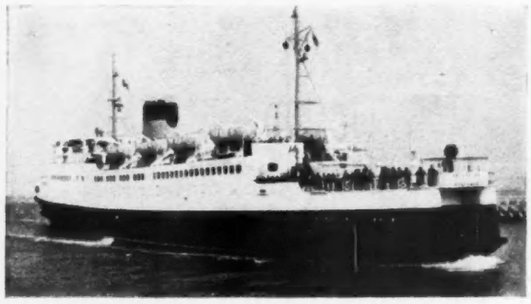

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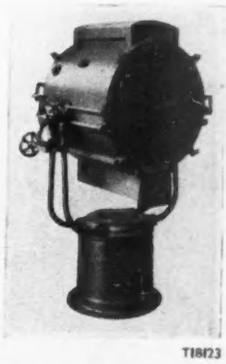

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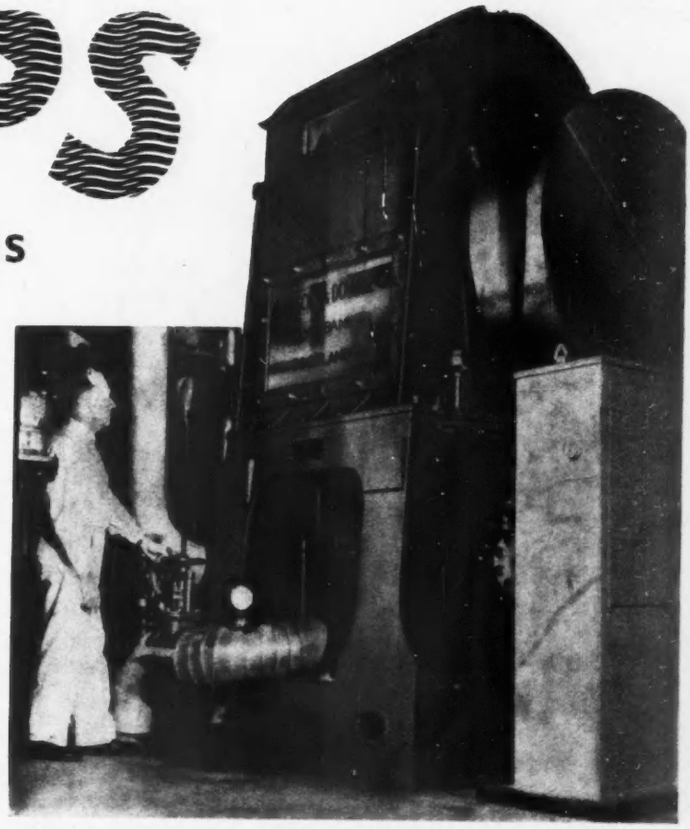

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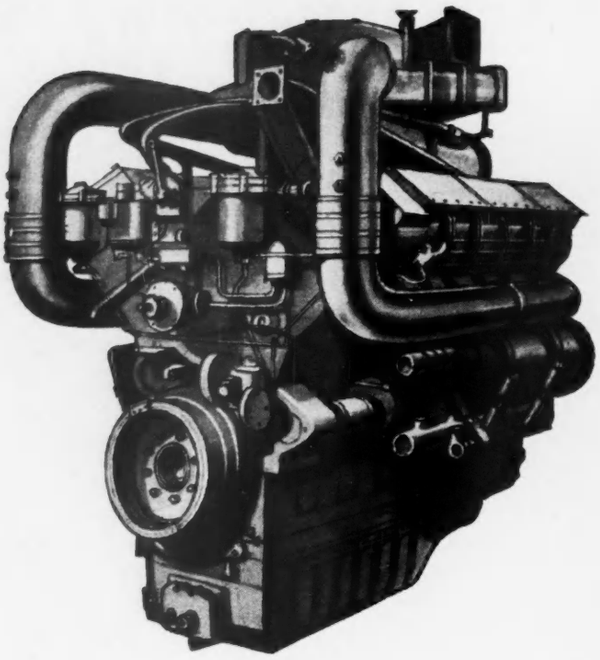
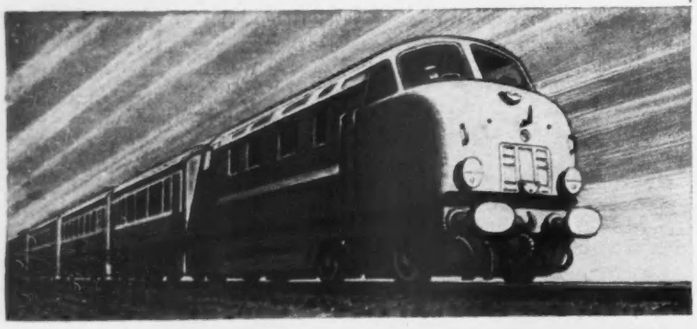


Typical of the MD range of engines is this Type 650 12 cylinder supercharged model with cylinders arranged in 'V' formation.



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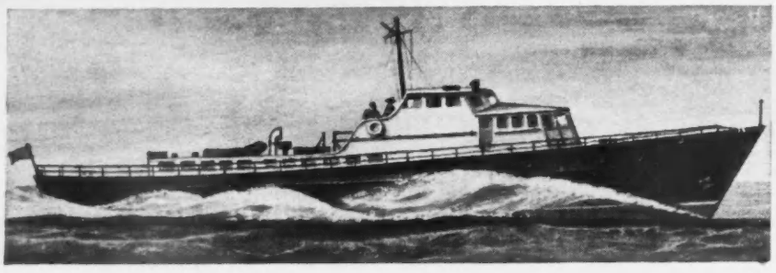

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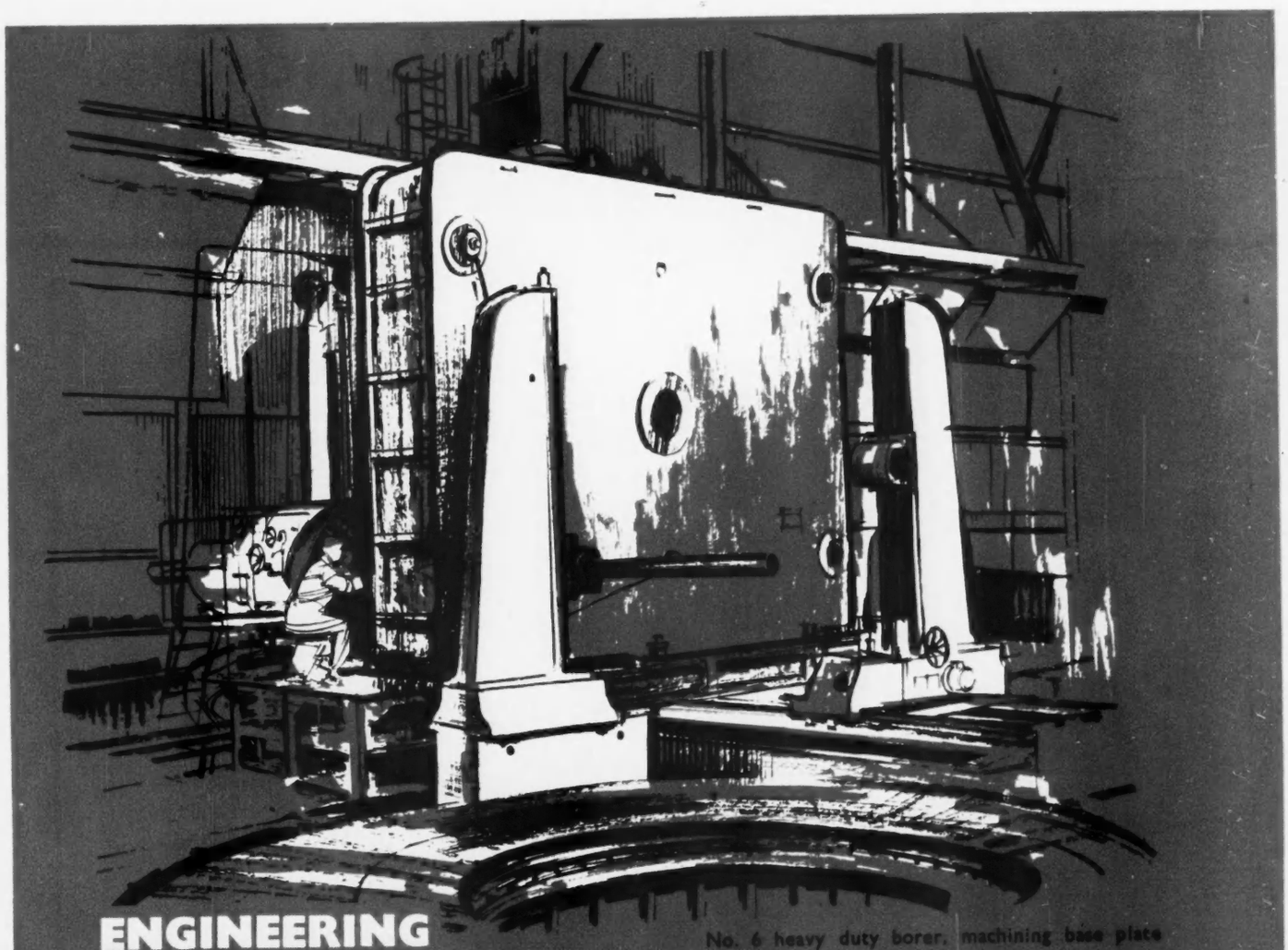

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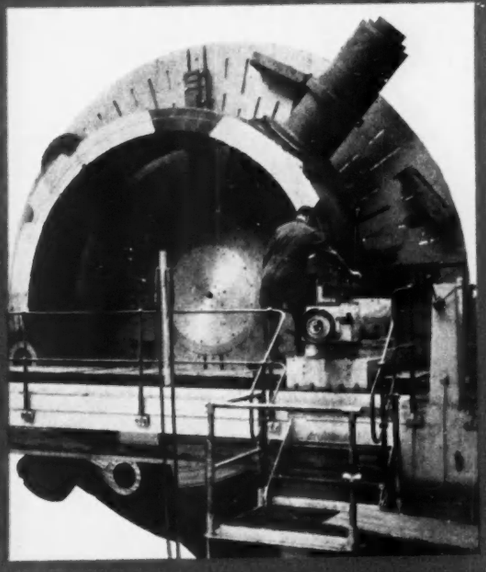

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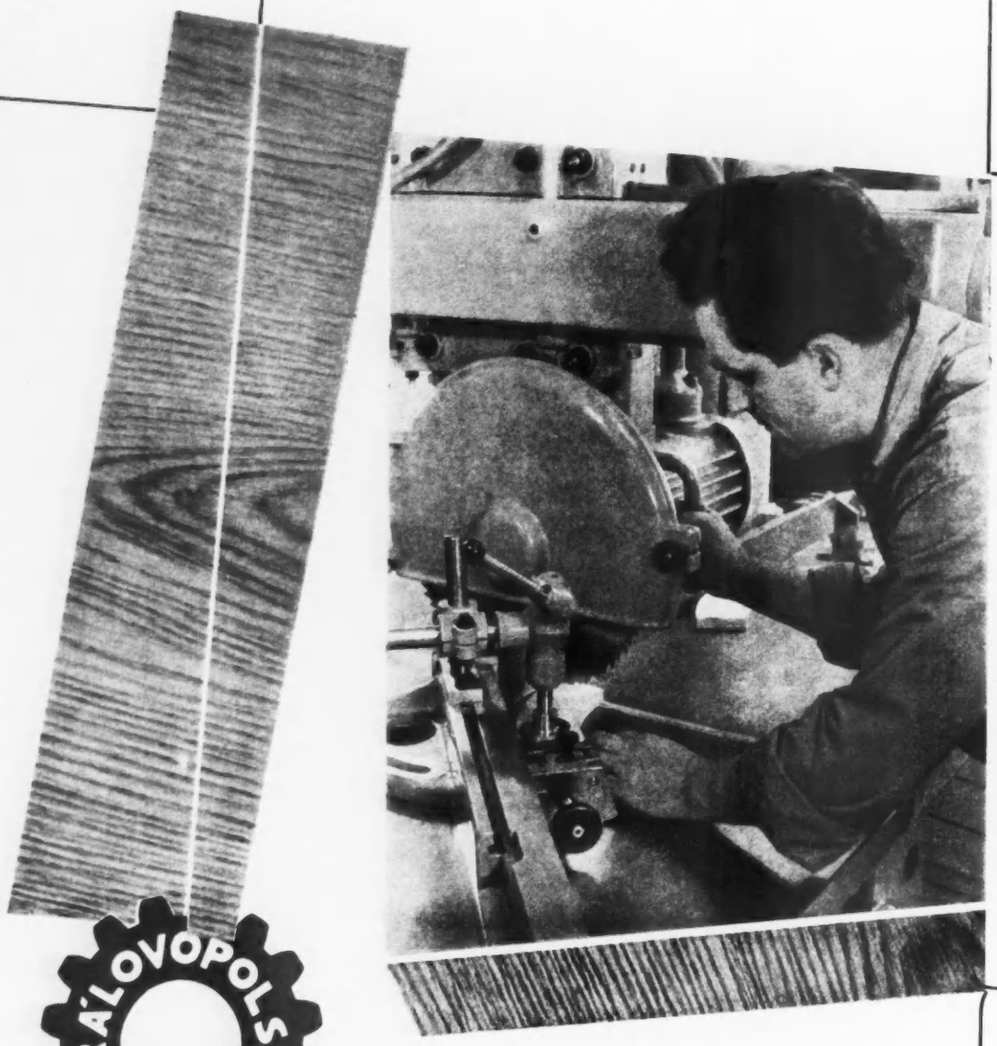

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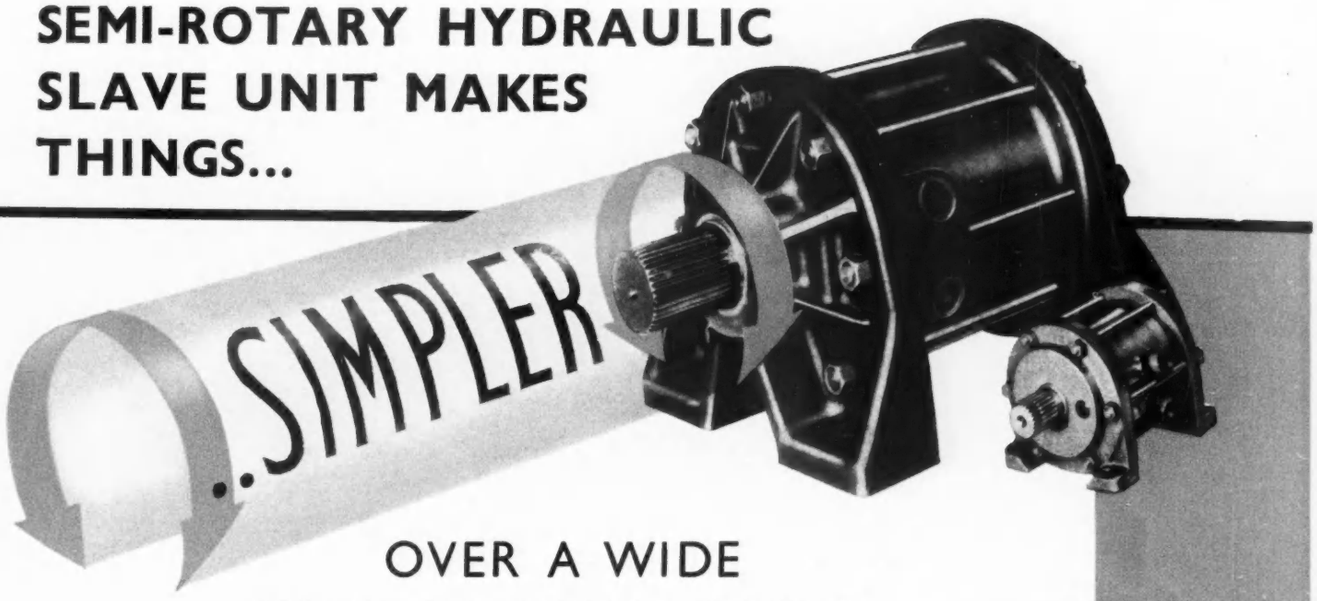

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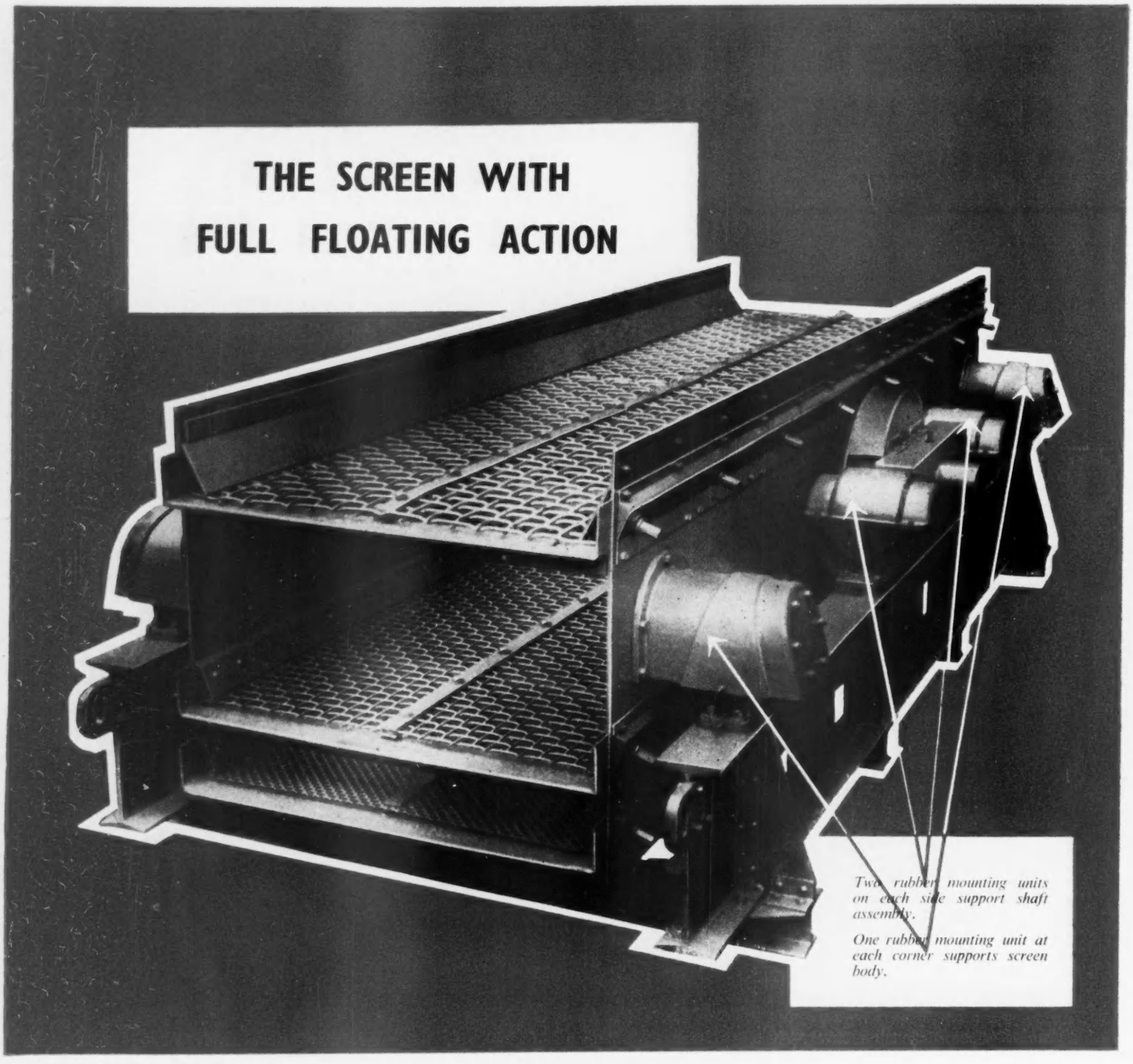
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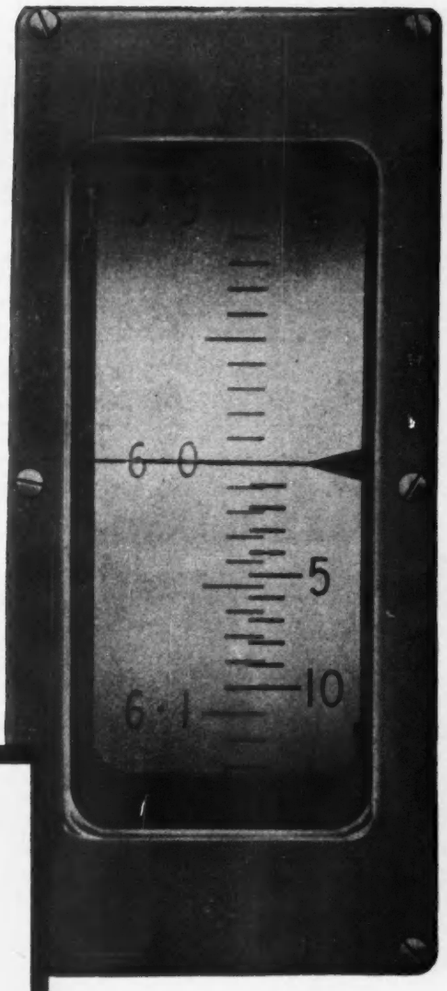

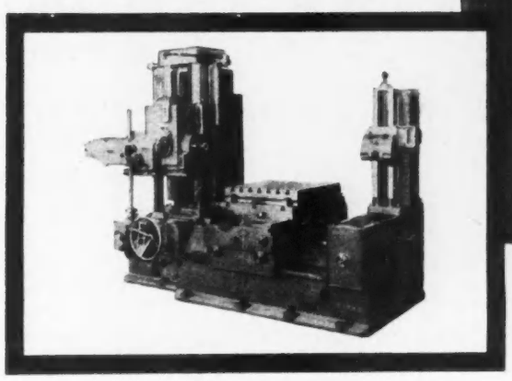

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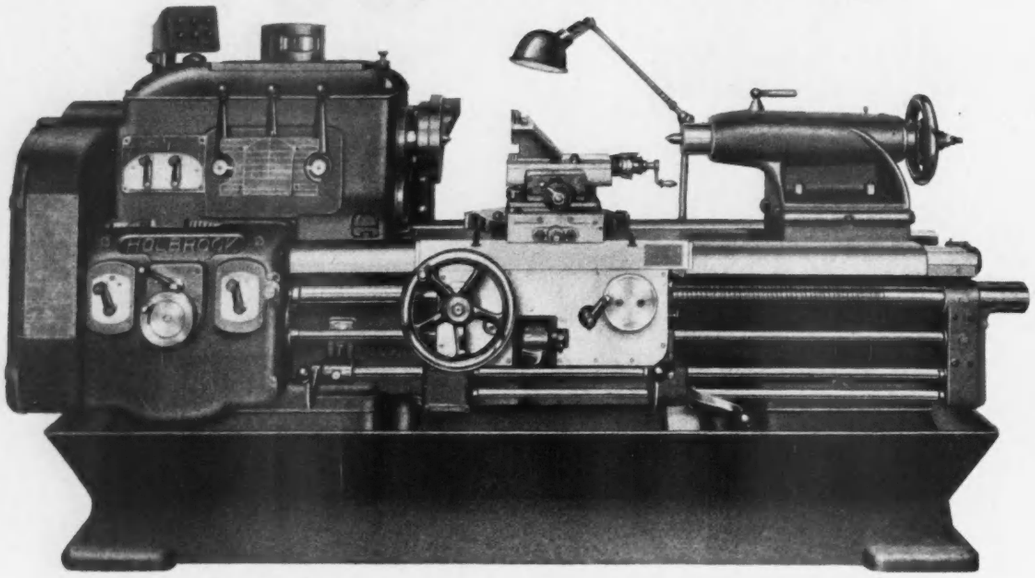

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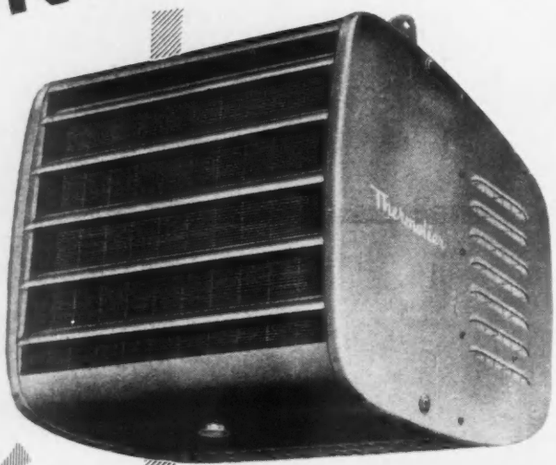

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REGISTERED DESIGN NO. 888398

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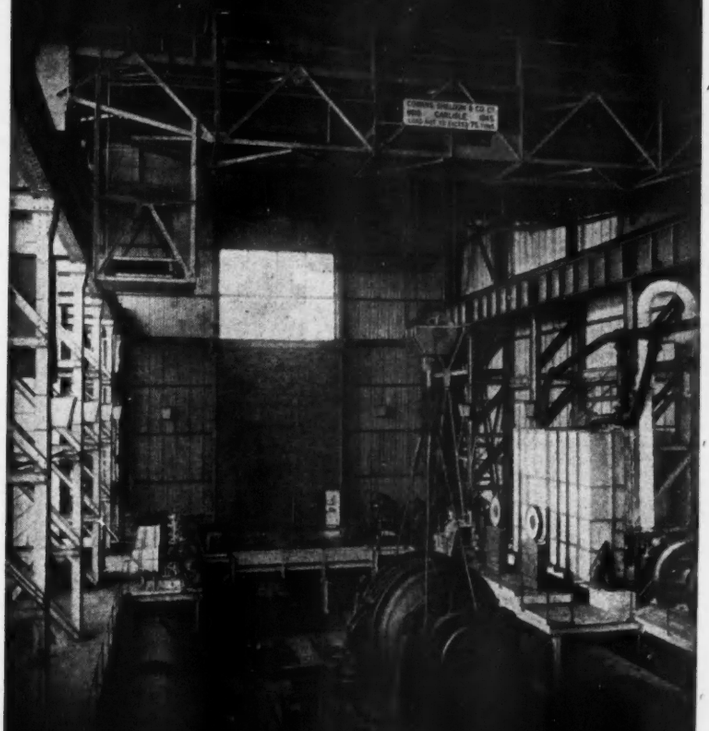

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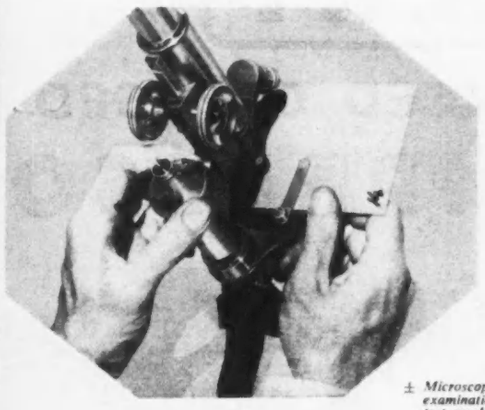

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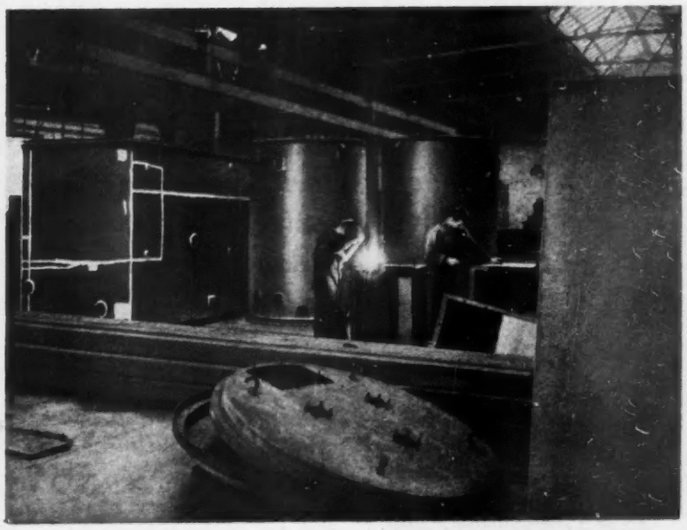

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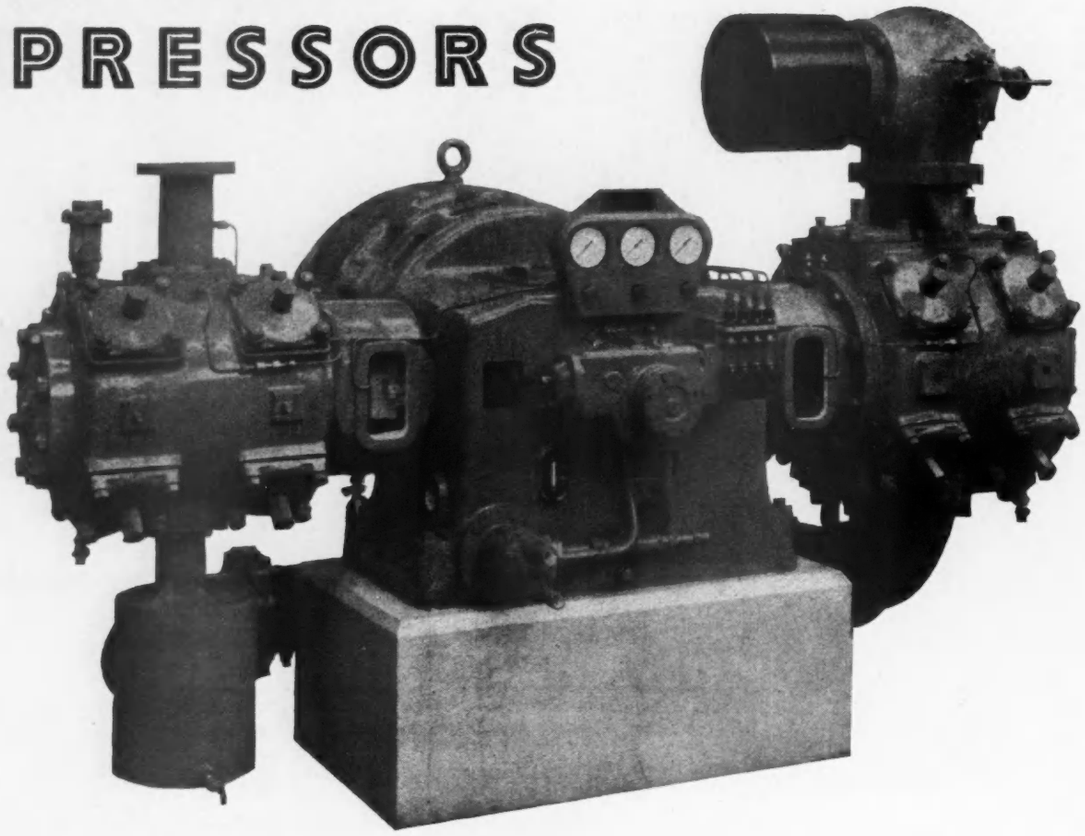
ALLEY

BALANCED OPPOSED COMPRESSORS



The long established high quality of Alley Compressors is combined in these machines with the known advantages of the horizontally-opposed design.

COMPACTNESS: Intercooler lies below motor. Motor is built on.

BALANCE: No horizontal or vertical out-of-balance forces.

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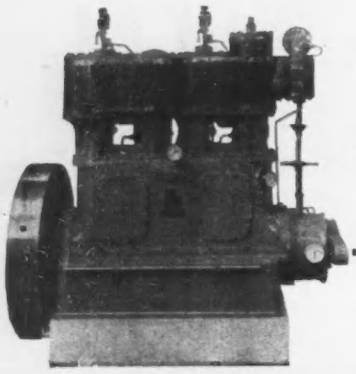
Can be installed on a minimum foundation—even on an upper floor.

The unit is complete—intercooler and oilcooler incorporated—ready for bolting down.

Range of single and two stage machines up to 10,000 c.f.m.

A corresponding range of VACUUM PUMP is available with displacements up to 12,000 c.f.m.



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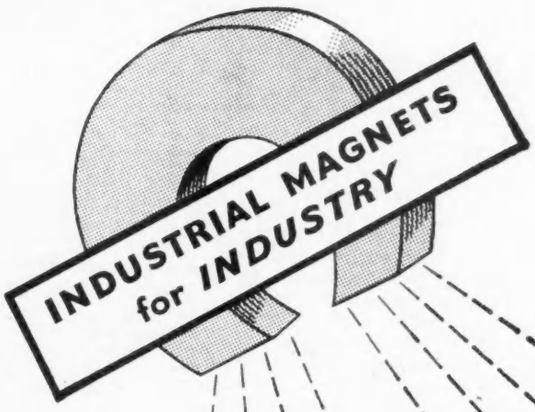
THE ALLEY B/L STEAM ENGINE: A high class range of single and two cylinder engines of compound and non-compound type, with outputs ranging from 40 B.H.P. to 750 B.H.P.



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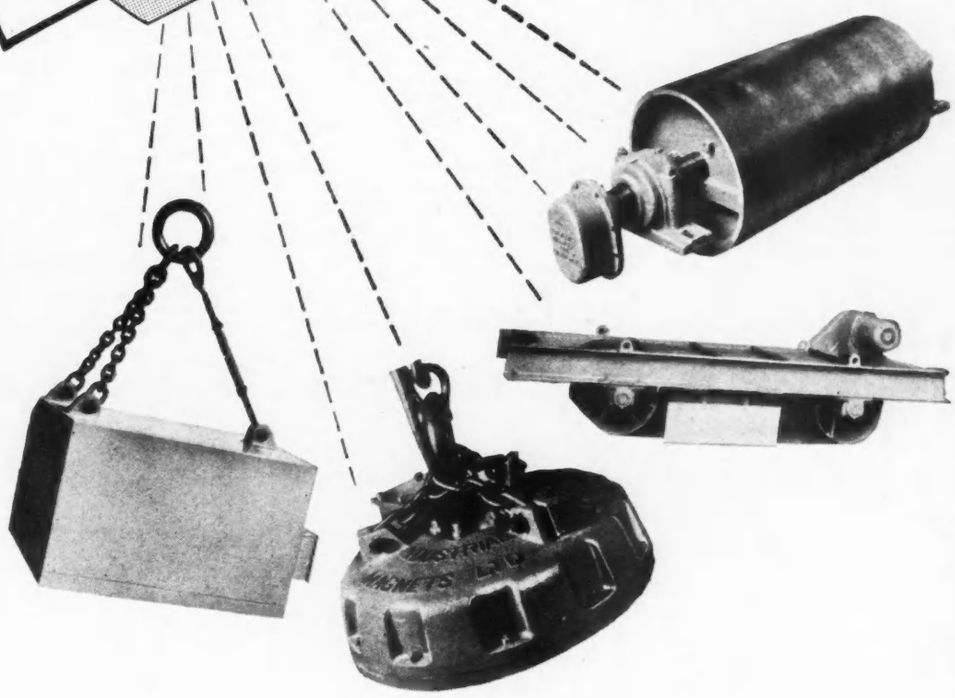

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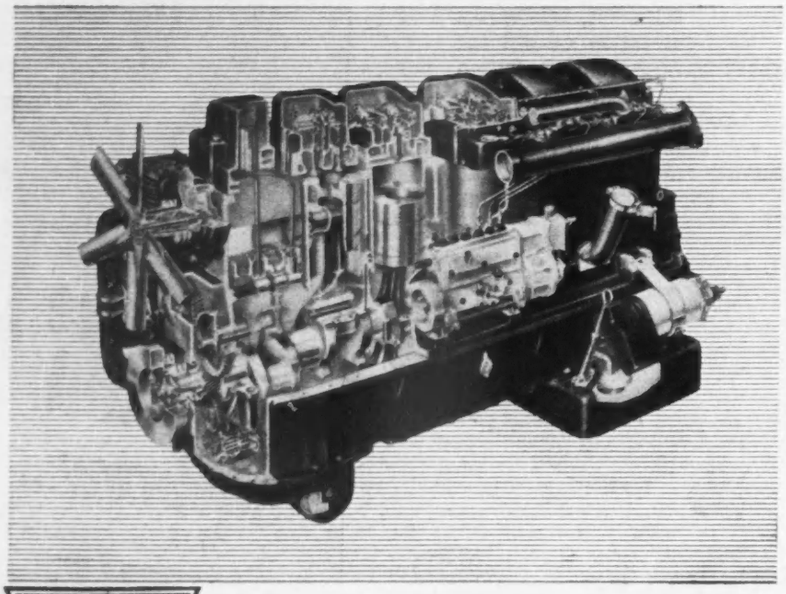

For earth moving equipment of every type there's now an A.E.C. diesel that's just right for the job. Normally aspirated, Southall-built industrial engines range from 50-275 b.h.p.: turbo-charged they go up to 360 b.h.p. and provide the most compact economical units it's possible to buy. They're designed to give high torque and sustained or intermittent rugged power wherever and whenever it's needed . . . for unfailing reliability in the severest conditions . . . for long trouble-free working life. And wherever they are operated they are backed by A.E.C.'s world wide service facilities. That's why, when it's a question of power, the answer is . . . A.E.C.

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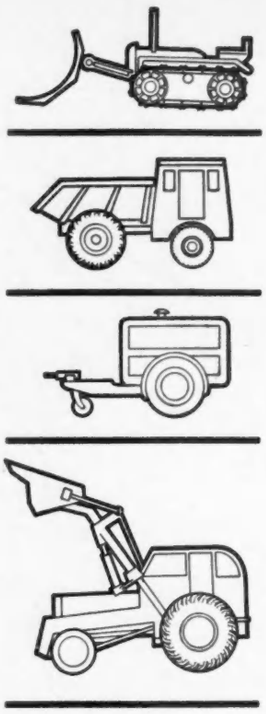

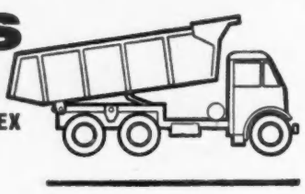

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DISCOVER NEW WAYS of cutting time and cost in making parts and components and for many types of repairs. DOUBLE BOND—an entirely new material—can be used for jointing, filling and moulding, or fabrication of actual parts. This versatile self-setting structural plastic is available in two grades; one moulds like putty for filling in depth, the other spreads like cream for shallower and larger areas. Both set like lead, machine like brass and can be used as a cold solder. Write for 7/6d. trial pack which includes both grades.

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What it does . . .

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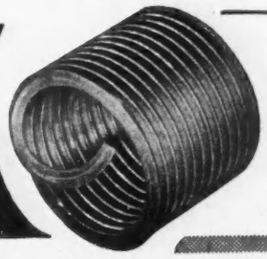

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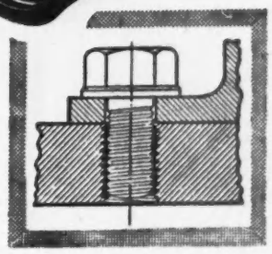
We also make Stainless and Bronze for other applications.



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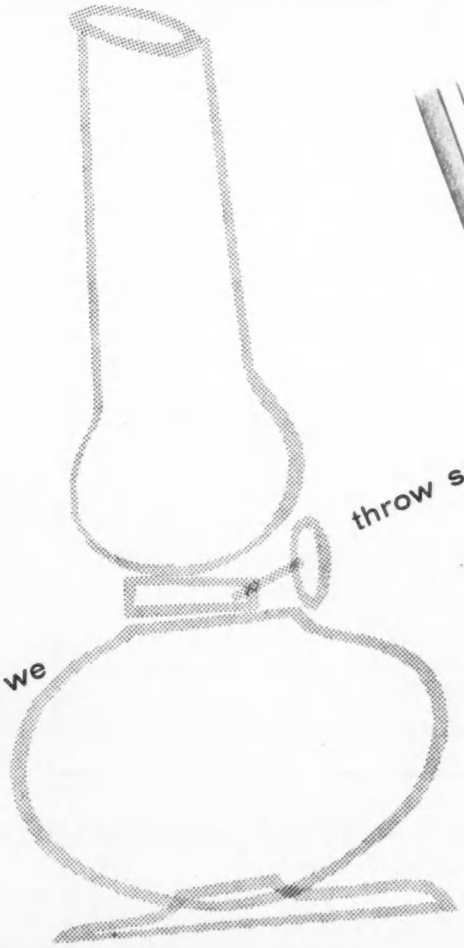
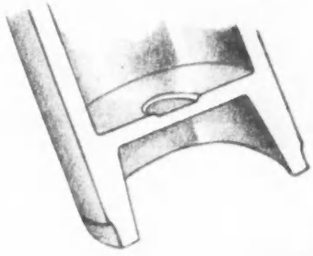
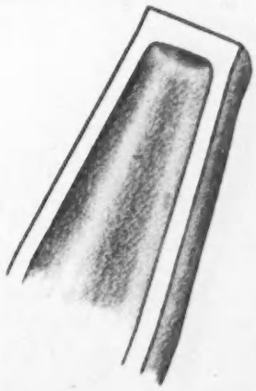
Specialists in JET ENGINE LABYRINTHS, CIRCLIPS, SPRING WASHERS, SPRINGS, etc.



may we throw some light on the subject of . . . hollow extrusions





. . . a light to guide the designer who seeks more efficient ways of making cylindrical products to close tolerances. In these precision hollow extrusions, the integral ends, with their wide possibilities for internal and external forms, obviate costly machining and assembly.

A leaflet explaning Reynolds Hollow Extrusions more fully will be sent on request, or our technical staff will be pleased to advise you.

REYNOLDS

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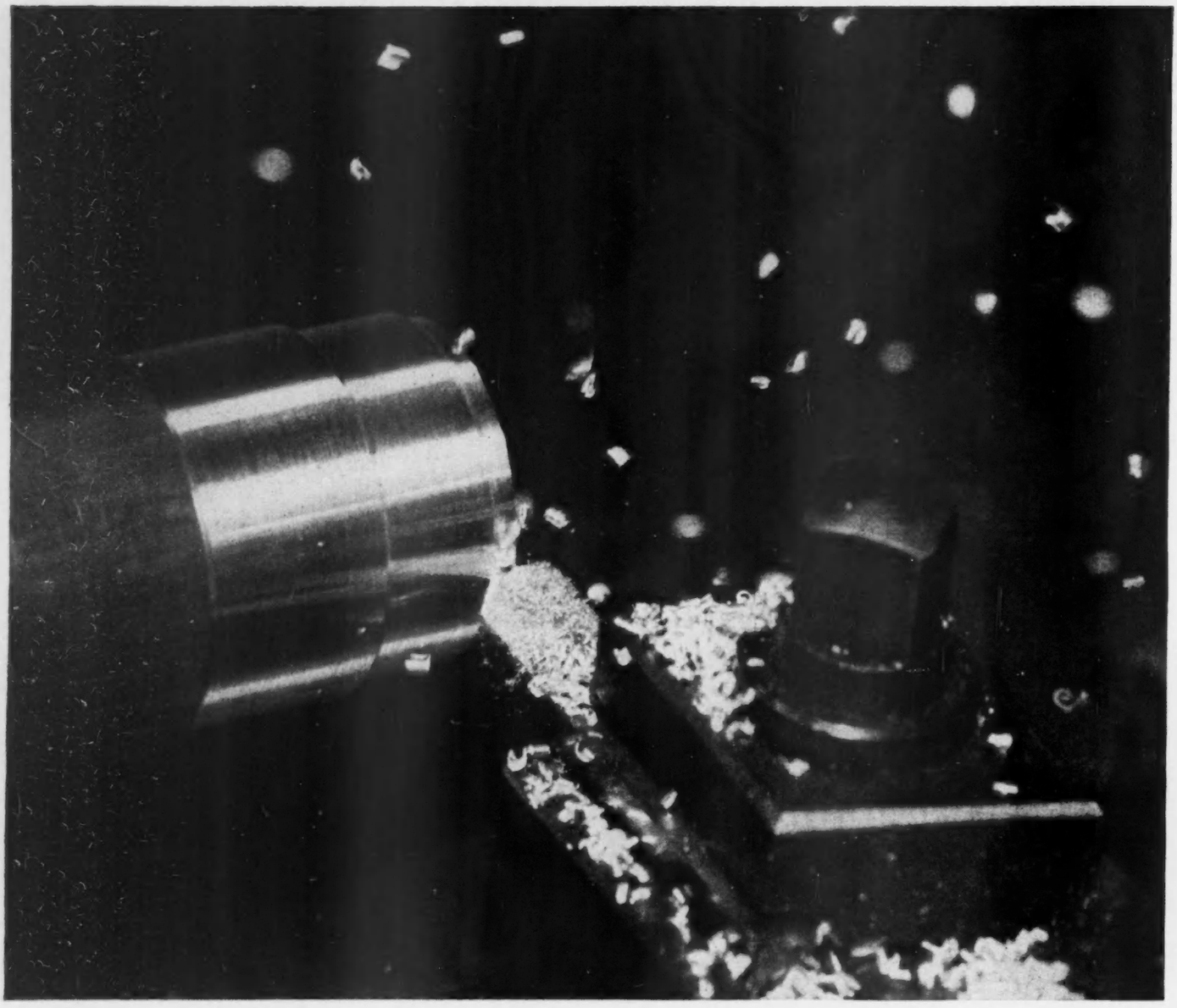

Headstock speed 610 r.p.m., Traverse .005 in. per rev., Depth of cut .05 in. using tool with no rake. Photo taken with high speed electronic flash at 1/5000 sec. and f.16.

DURALUMIN 'C' machines like this

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This photograph shows the results obtained from our aluminium alloy, Duralumin 'C'. This new addition to our range of light alloys has been developed specially for its outstanding machining properties and is meeting with remarkable success.

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TGA 180 116C

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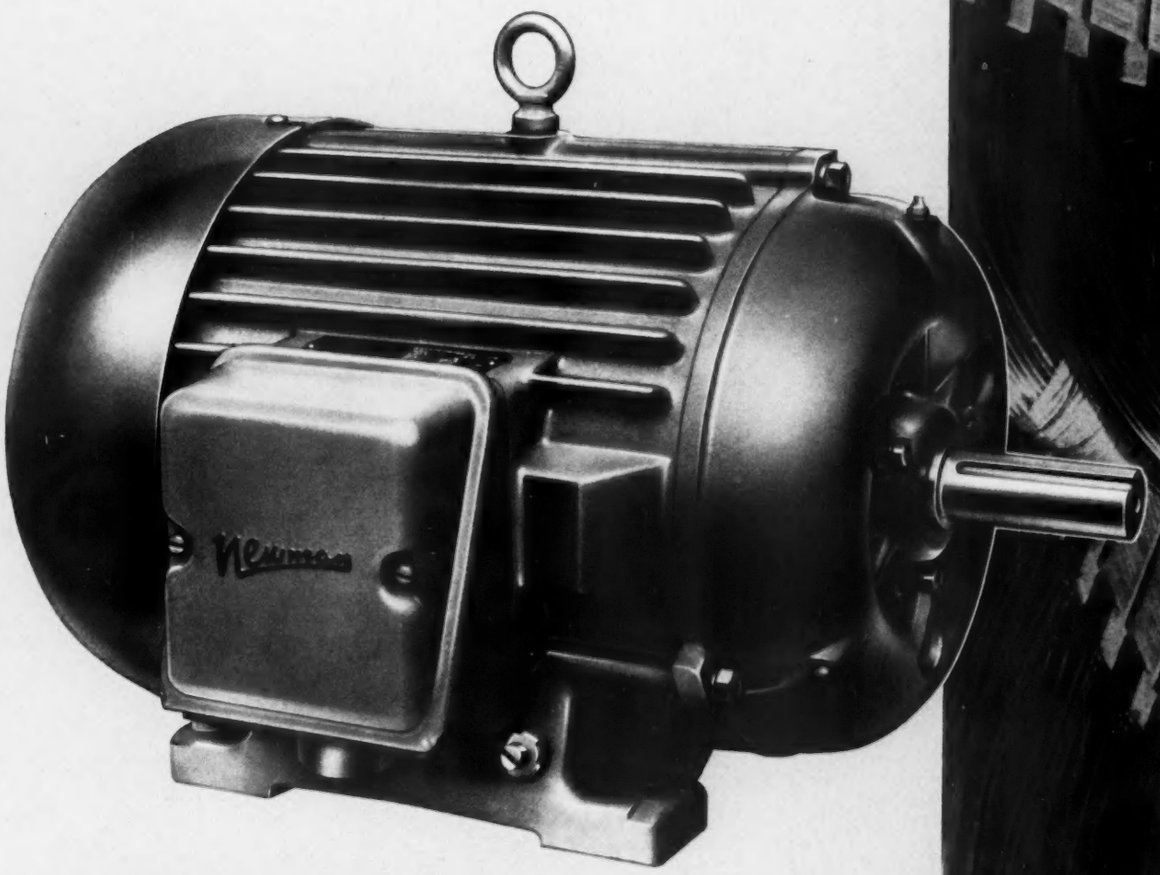
NEW FEATURES

allied to proved principles

INSULATION



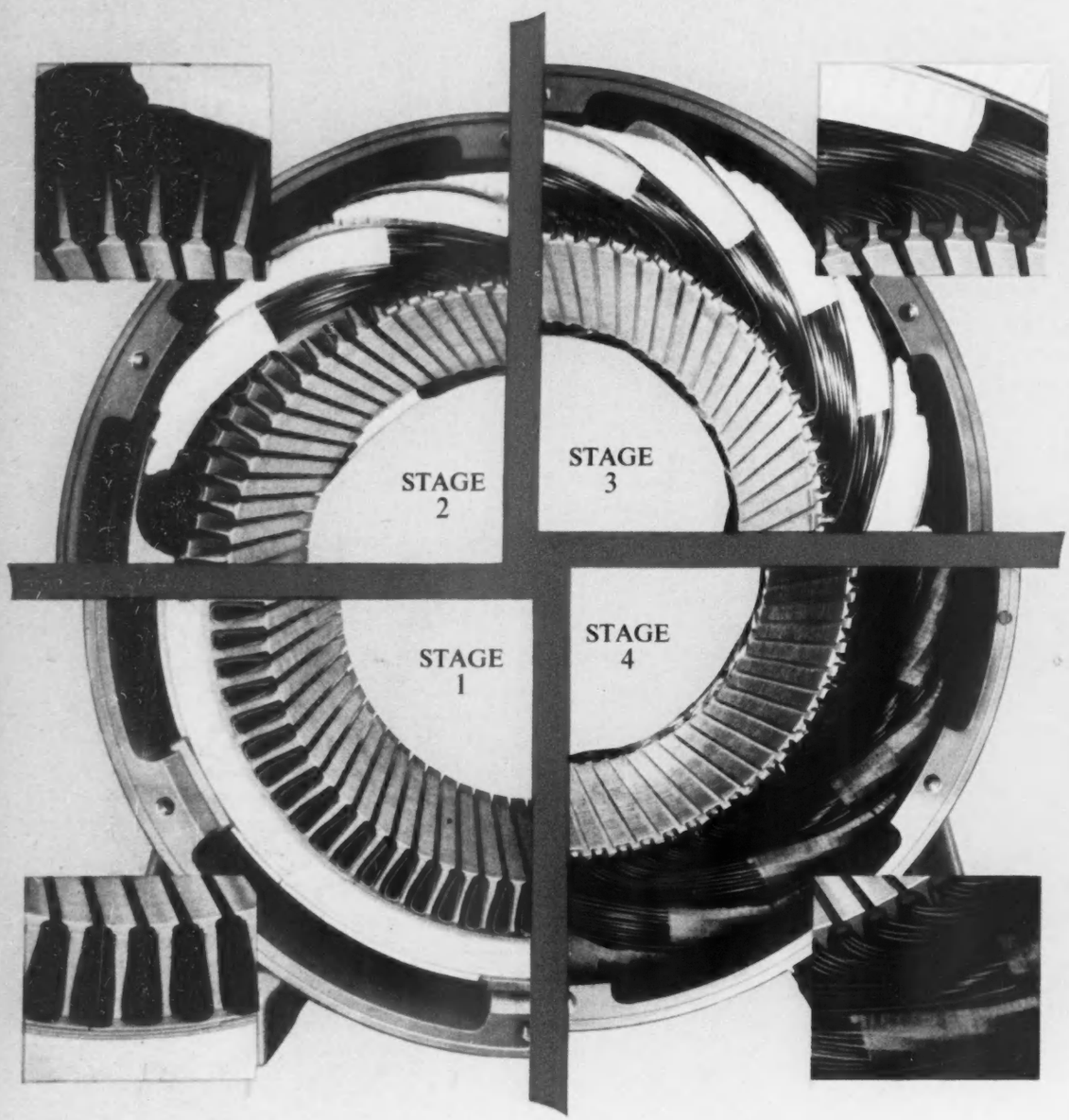
Newman

Making the pace
in motor progress

Newman INSULATION

FOR MAXIMUM ENDURANCE

The quality, efficiency and life of an electric motor depend directly on the quality of its insulation. The illustrations and diagrams on this page show Newman standard practice and thoroughness in design and construction. All materials are of the highest quality and are subjected to stringent tests. The following details concern the routine treatment for a standard Class E insulated drip-proof motor, but Newman are, of course, experienced in building motors of any class of insulation as well as motors specially treated for specific duties.



WIRE: High conductivity copper wire insulated with a vinyl acetal based enamel, conforming to BS 1844.

SLOT LINERS: Elephantide bonded to cellulose triacetate film; an insulation which is tough and has excellent dielectric properties.

END WINDING PACKING: Space between stator clamp ring and underside of slot liner is packed with insulating material to cushion windings when coils are subsequently formed.

COIL SEPARATORS: Cellulose tri-acetate film bonded to a strong leatheroid backing of similar strength to the liners.

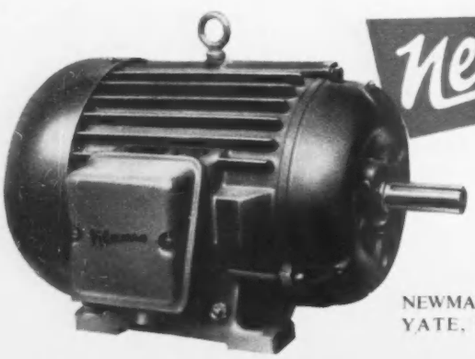
SLOT SHOES: Identical material to separators giving complete coverage to top coils.

SLOT WEDGES: Strong wedges hold windings firmly in slots.

BETWEEN - PHASE INSULATION: Elephantide, as for slot liners; maximum strength and excellent insulation. End windings bound with Terylene cord or tape to prevent movement. Coil Ends and all connections brazed and then sleeved with Terylene. All leads to block insulated with polychloroprene—oil resistant and unaffected by extremes of climate.

IMPREGNATION: Automatically controlled cycle during which wound stators are dipped in synthetic resin varnish, baked at a moderate temperature first to evaporate the solvent and then at a higher temperature to cure right through. Viscosity of varnish is carefully controlled.

This treatment puts a protective coating on the winding and renders it resistant to moisture.



Newman **Electric Motors from ⅛ to 600 H.P.**

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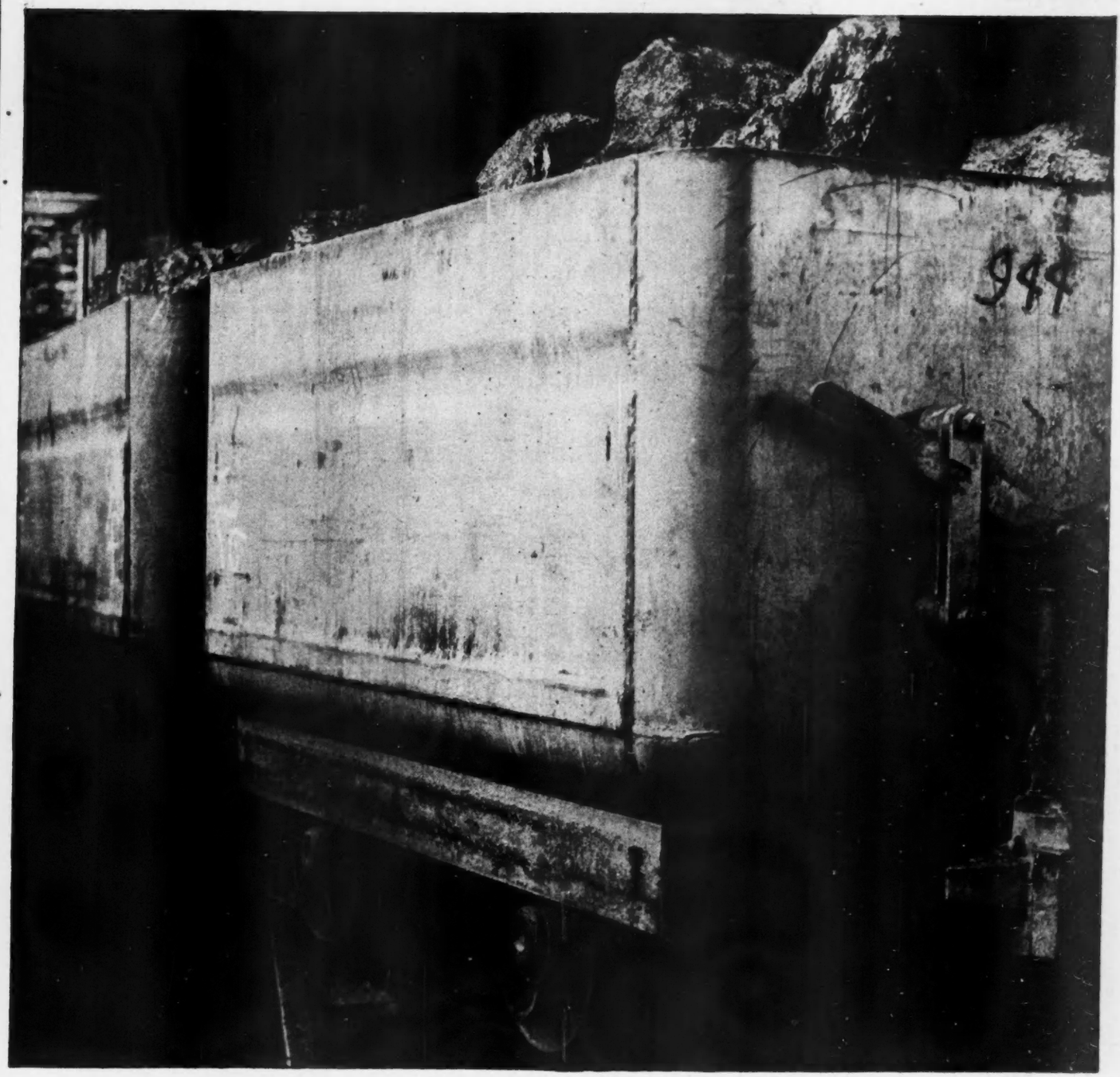
NEWMAN INDUSTRIES LIMITED
YATE, BRISTOL, ENGLAND



Mine cars made from SCW Cor-Ten (Photograph by courtesy of the National Coal Board)

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Where advantage can be taken of its high yield strength and corrosion resistance, SCW Cor-Ten can always effect a substantial cost saving.

Whatever the application (and the range continues to grow) SCW Cor-Ten is able to offer an unchallengeable combination of economy and efficiency.

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THE STEEL COMPANY OF WALES LIMITED

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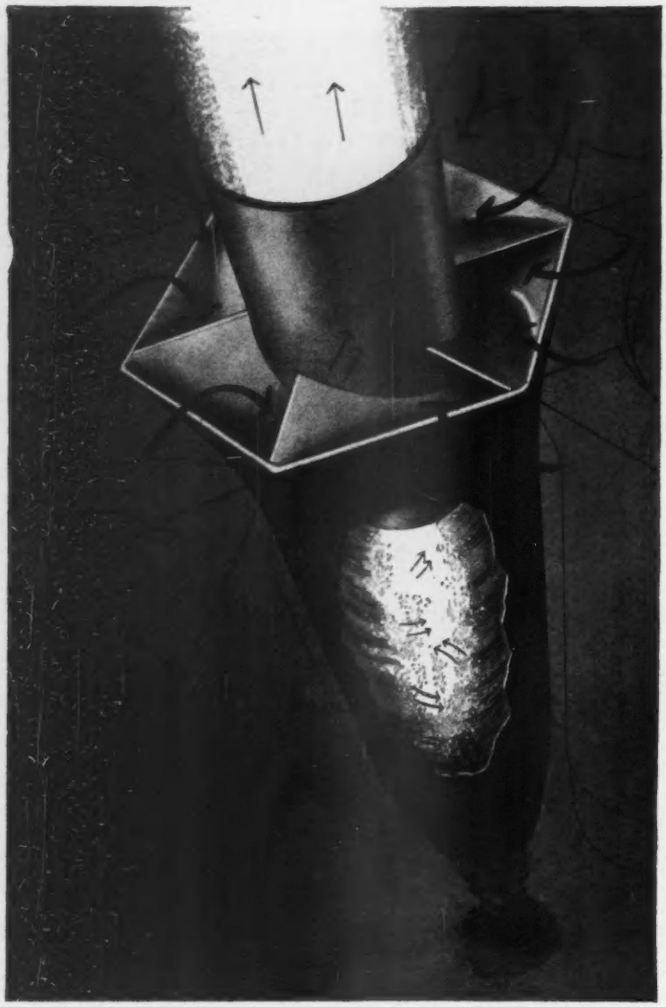

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If you have a dust removal problem, have a word with Steels and 'clear the air'.

Compare these advantages with existing methods —

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Erosion is reduced to a minimum because the large particles are collected at low velocity, only the very small particles being accelerated to higher velocities necessary for collection:

Simplicity of design affords speedy, easy installation and maintenance.

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Low power consumption.

Small installation space.

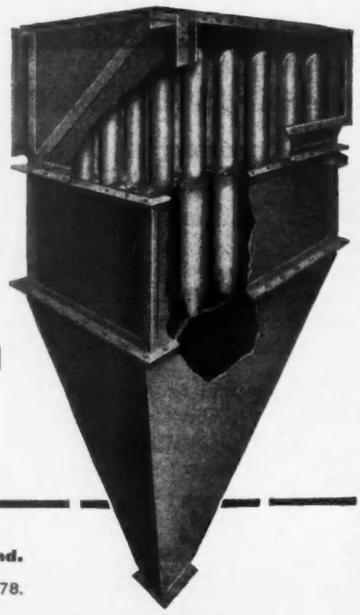
Maximum economy in product recovery.

Sturdy construction.

Factory assembly ensures dimensional precision and rigidity.

Hundreds of satisfied users throughout Europe and the U.S.A. testify to the efficiency of this system

S SELECTIVE
P PARTICLE
A ACCELERATION



STEEL

STEELS ENGINEERING INSTALLATIONS LTD., Crown Works, Sunderland, England.

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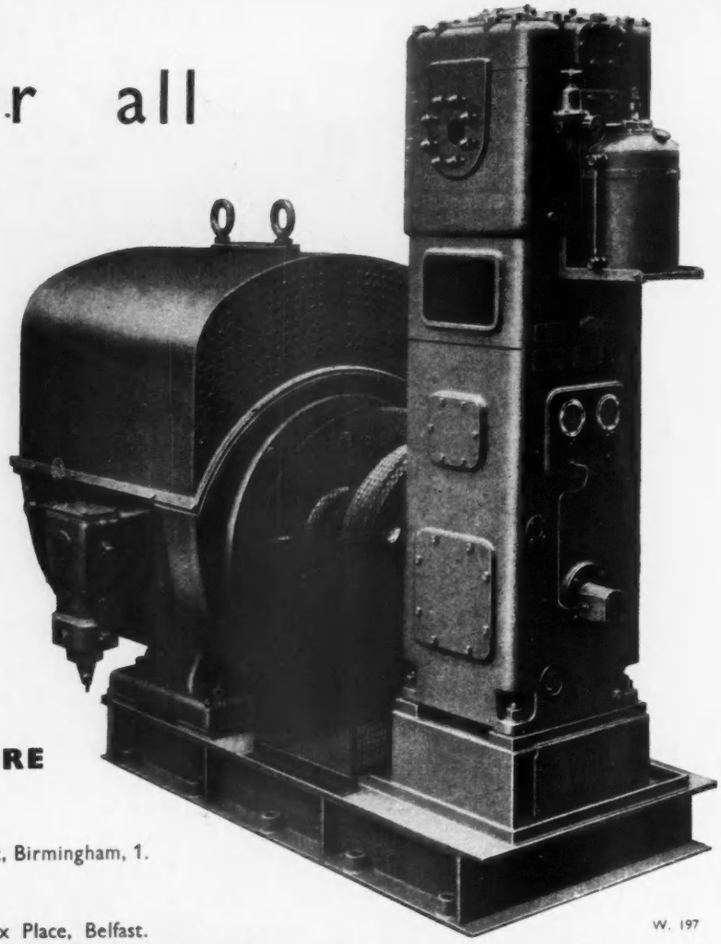
TILGHMAN'S for all compressor requirements



One of two machines supplied to Messrs. Petrochemicals Ltd. through the Lummus Co. Ltd. These machines have been supplied to boost the pressure of nitrogen from 50 lbs. p.s.i. to 230 lbs. p.s.i. This is an oil-free machine, but due to the very high dryness factor of nitrogen normal carbon rings would be liable to disintegrate due to the lack of moisture in the gas. This compressor is therefore fitted with a special water injection system which sprays a measured quantity of water into the cylinder to keep the carbon rings moist. The machine is direct coupled to a flameproof motor.

TILGHMANS LIMITED
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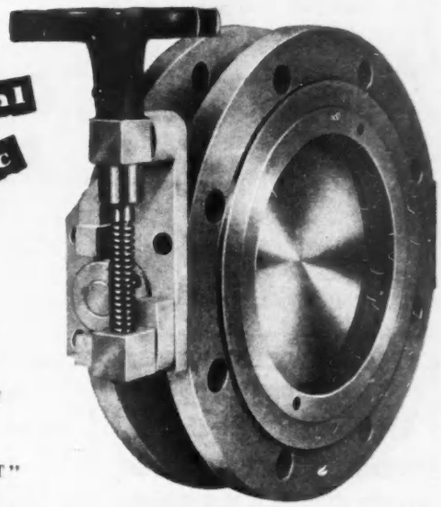

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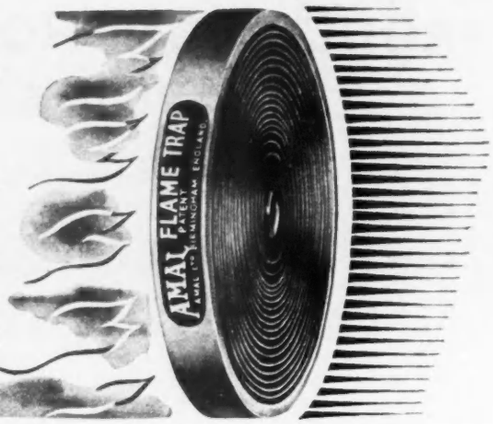

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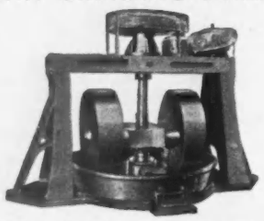

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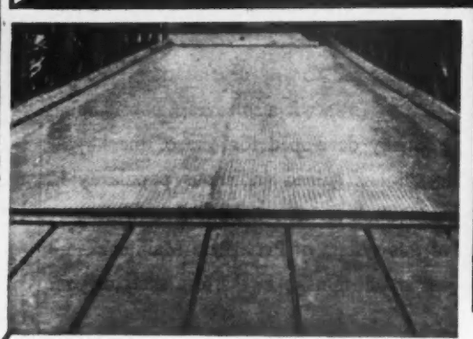

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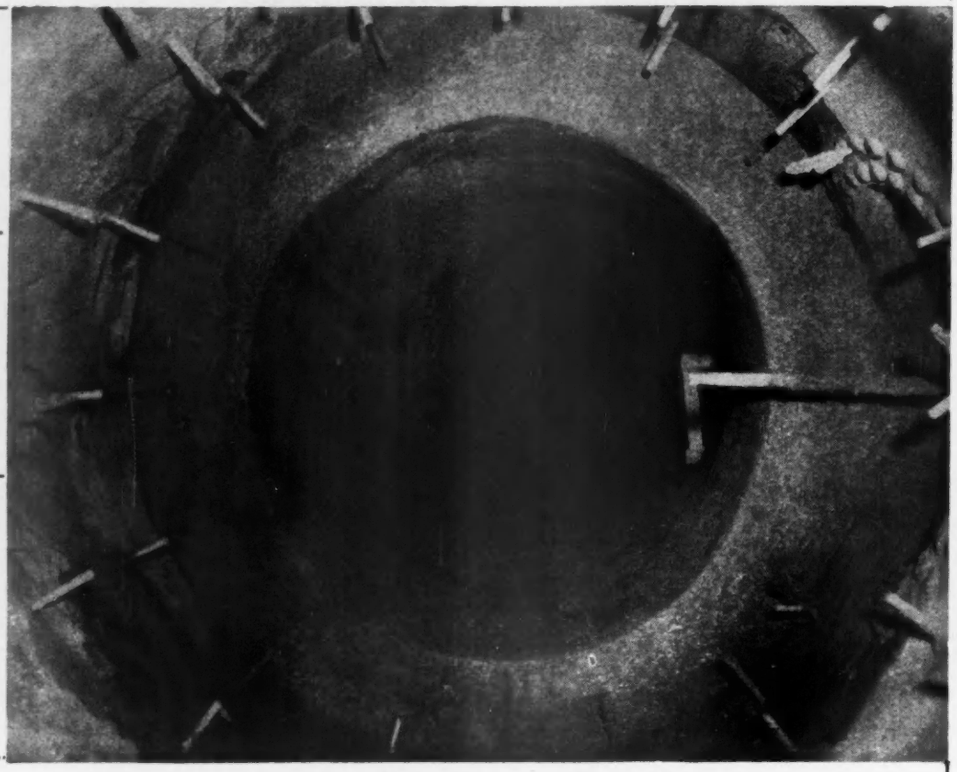

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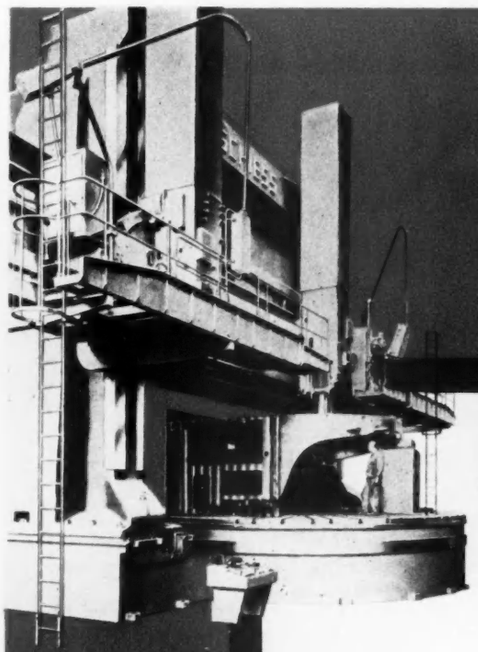

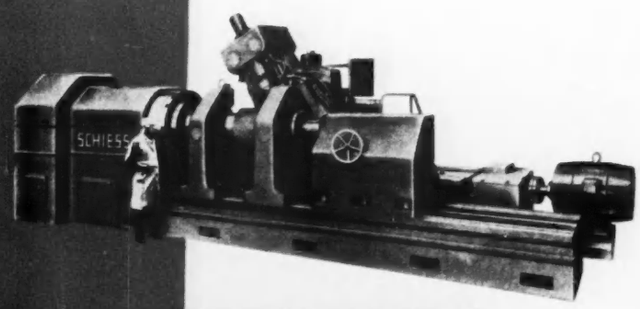

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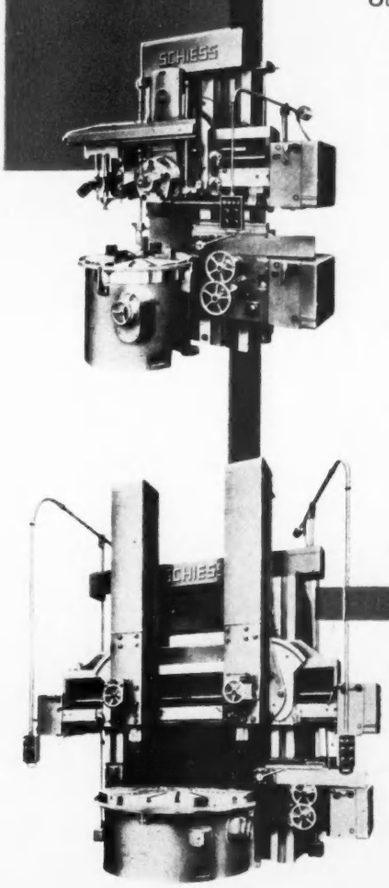

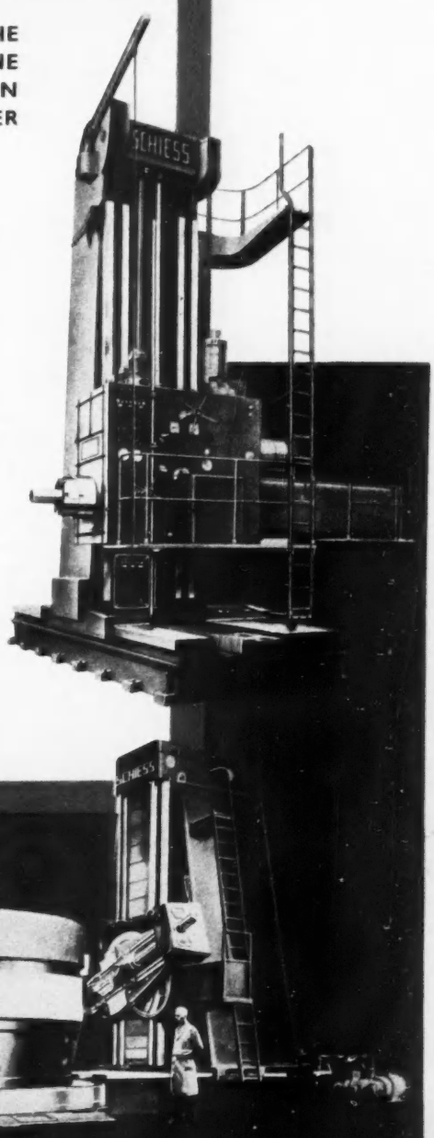

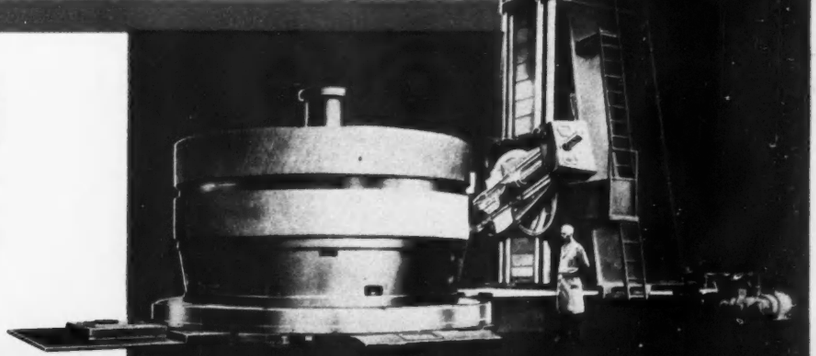

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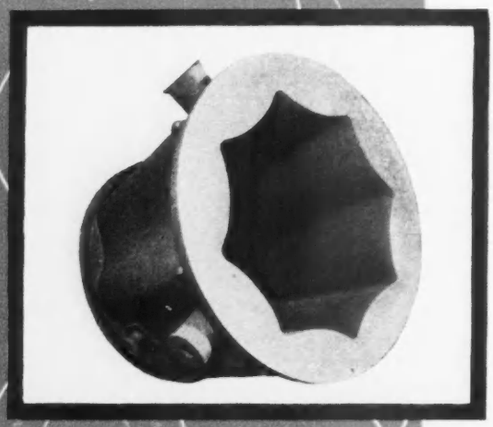

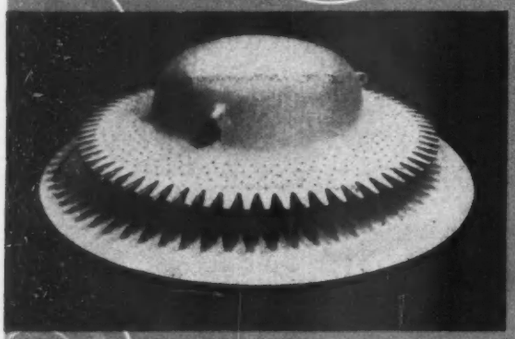

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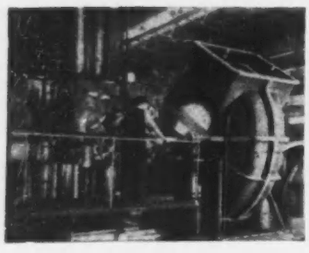

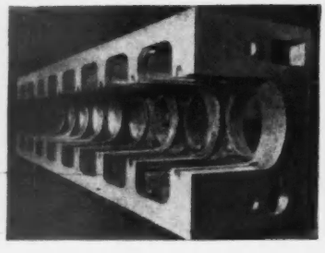

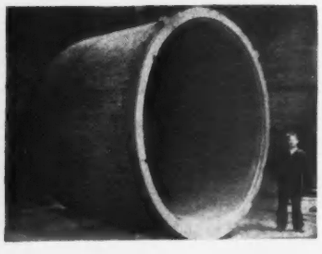

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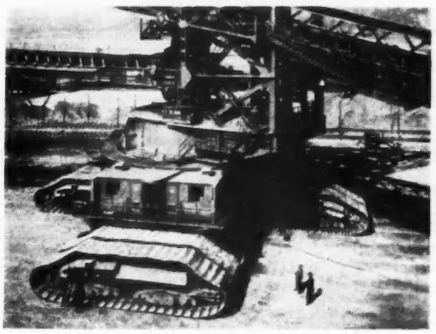

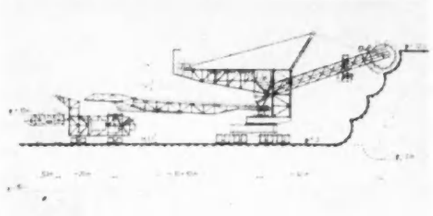

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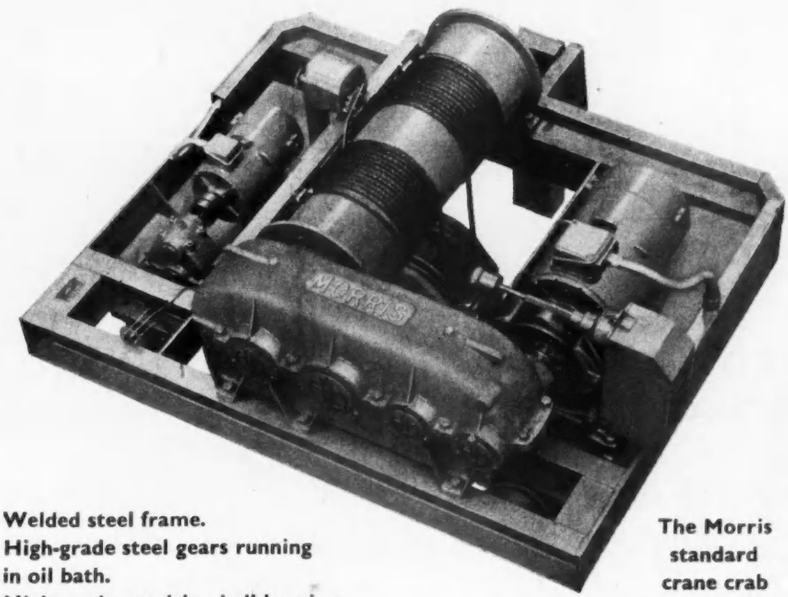

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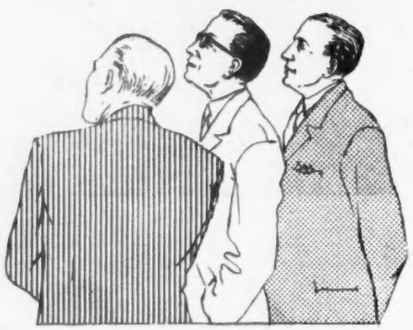

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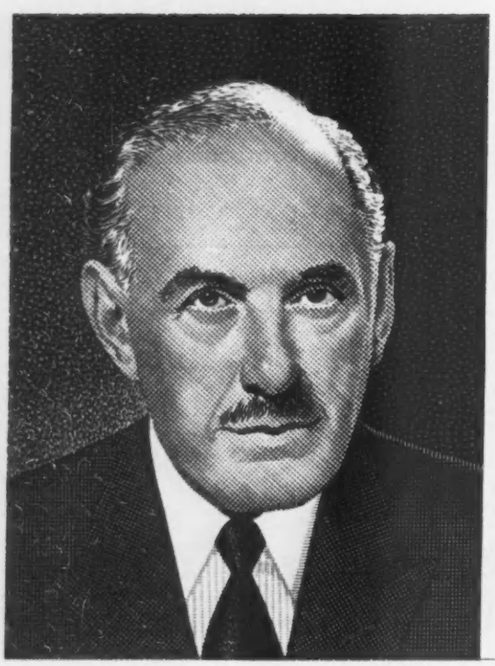

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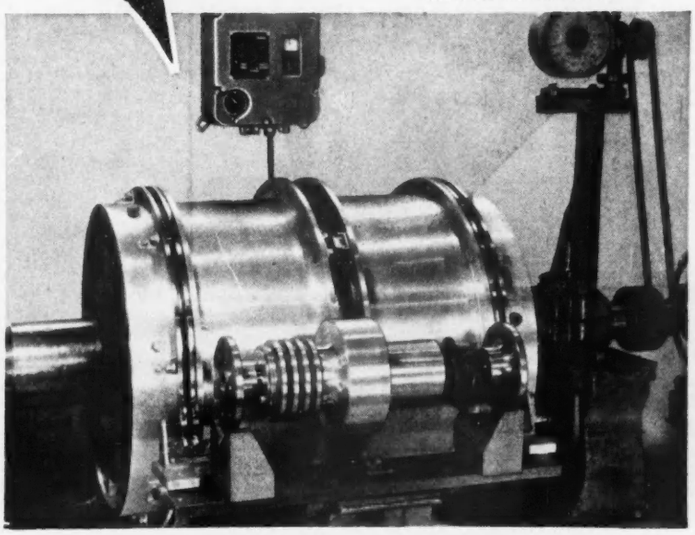

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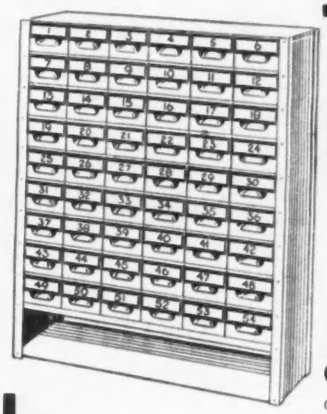

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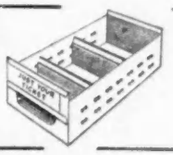

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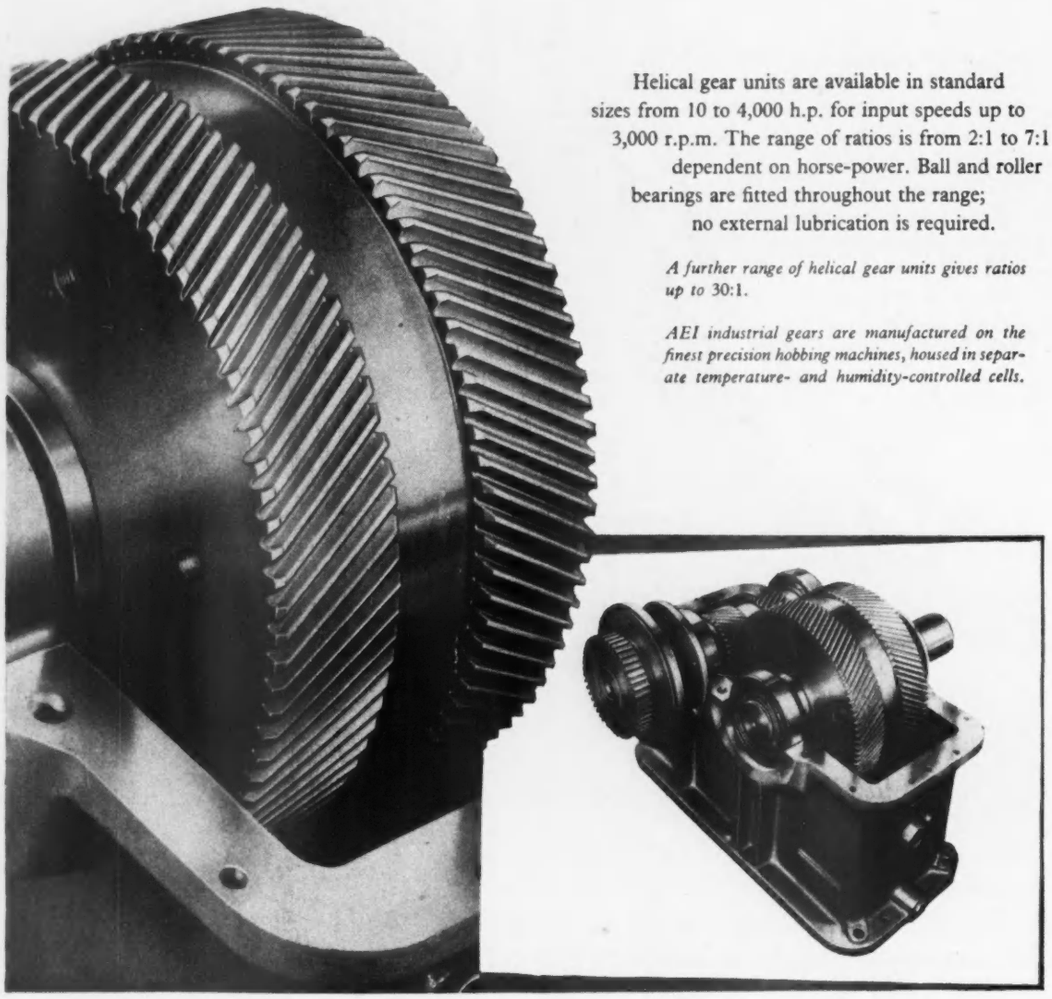

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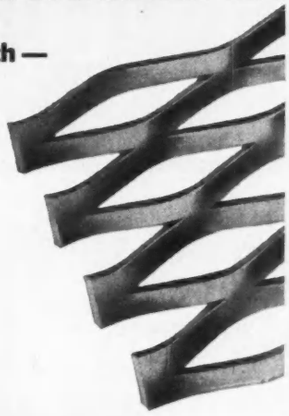

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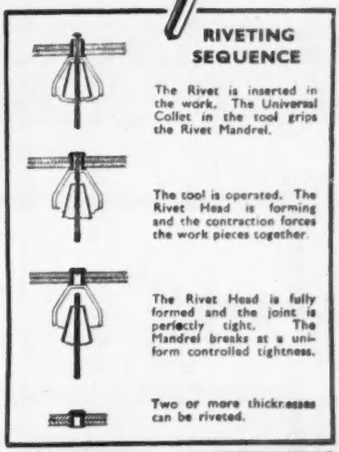
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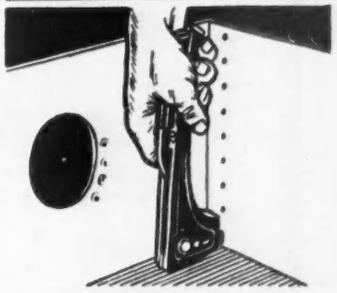

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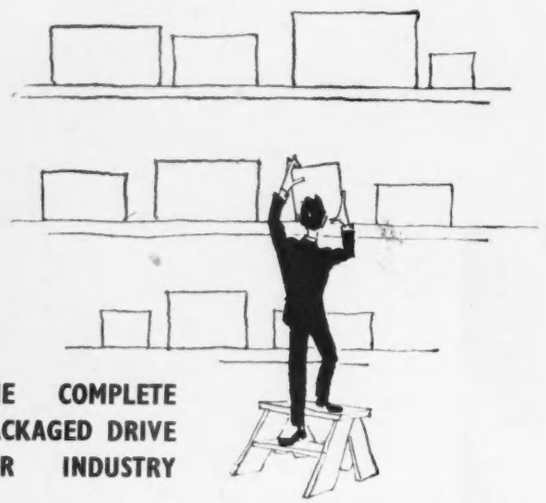

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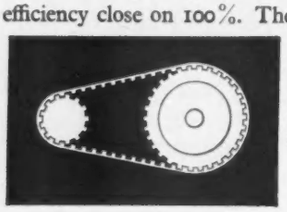

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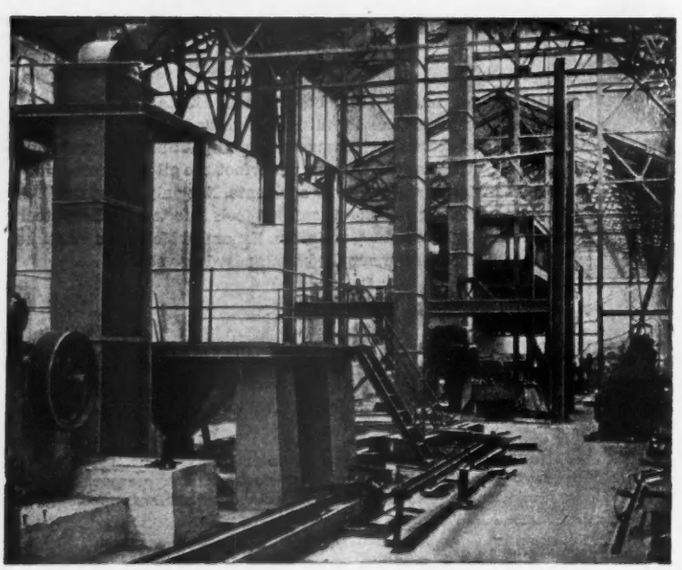

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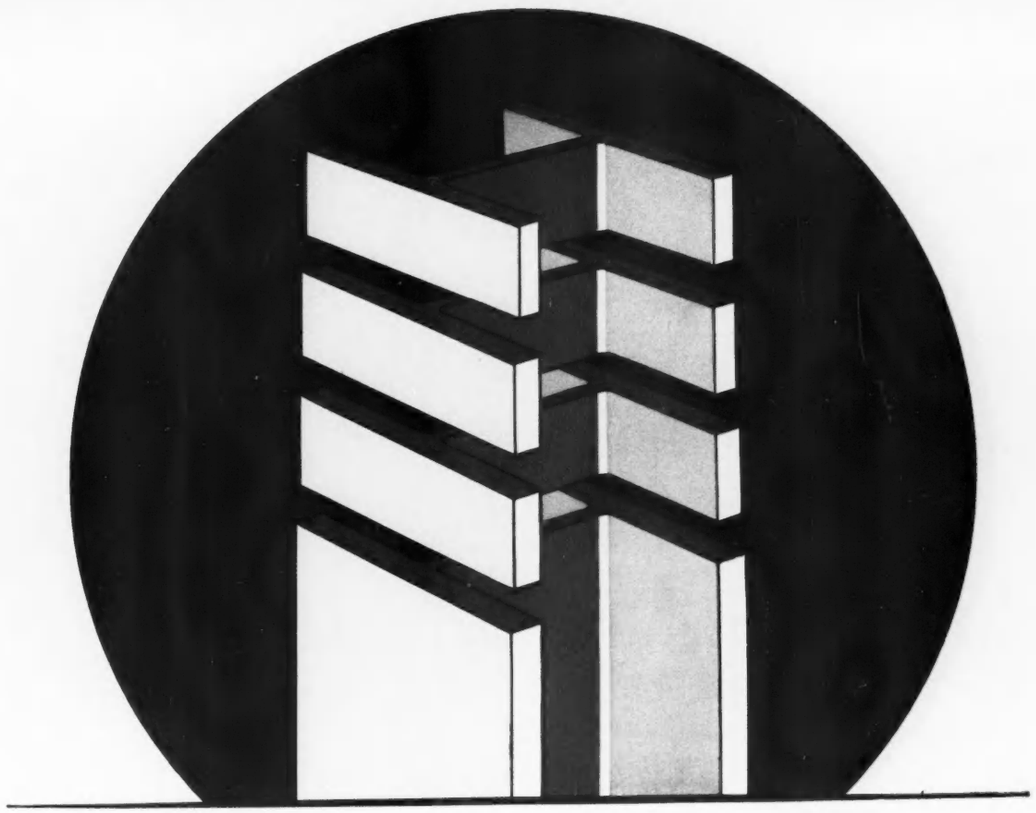

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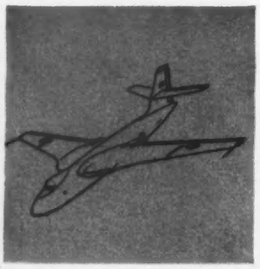

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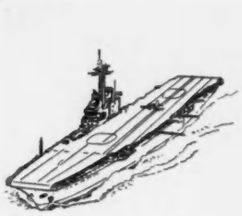

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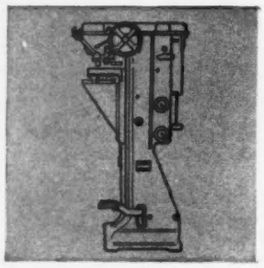

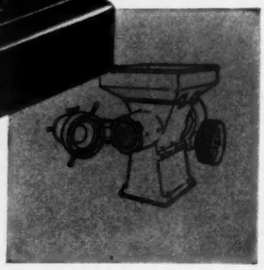

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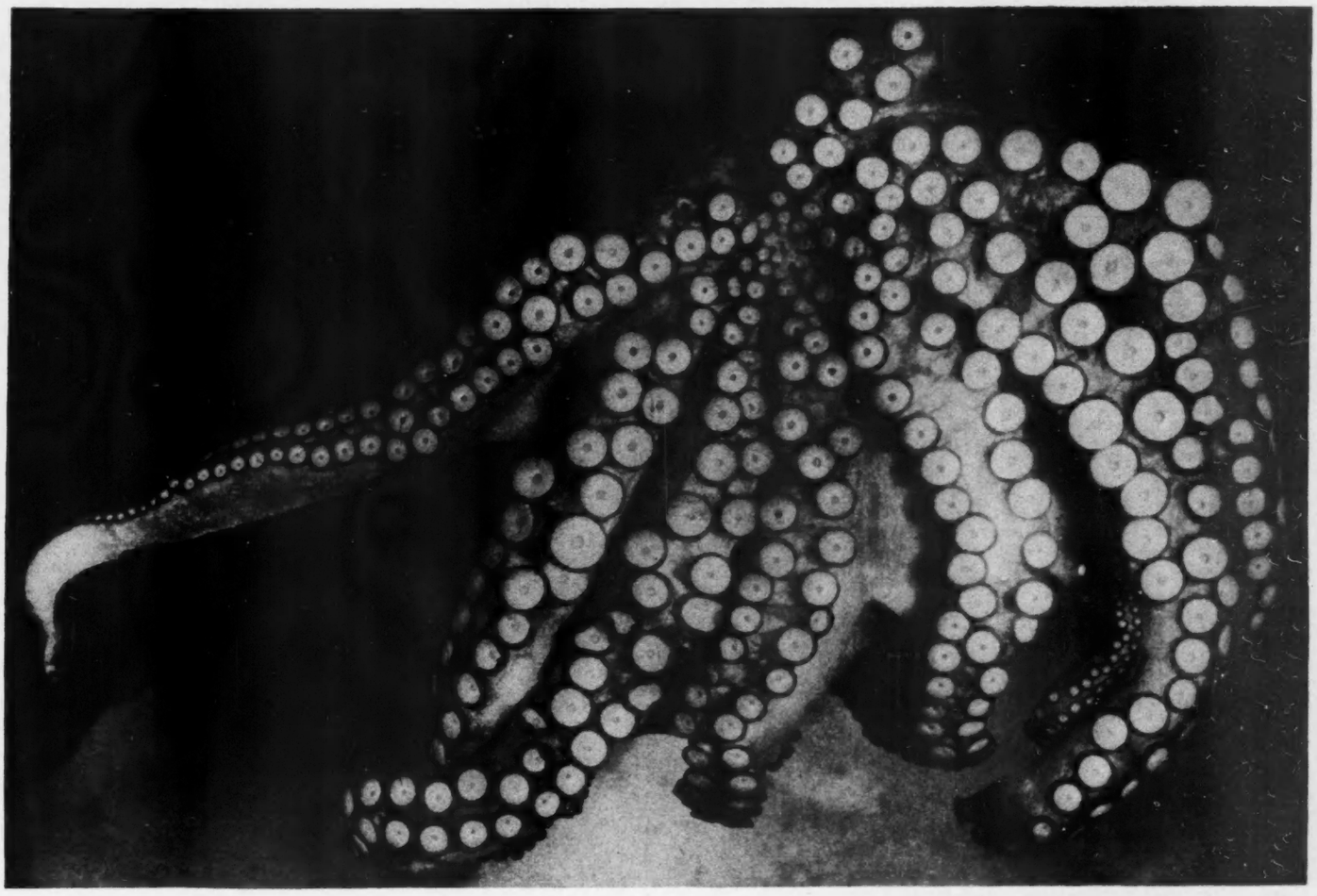

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The second associated problem was oxidation promoted by yellow metal cages. Could this be reduced? The answer, in Shell Alvania, is the virtual suppression of the effects of yellow metal.

Problem three was corrosion caused by moisture. Could this be prevented? The answer was given in the Thornton Wet Bearing Rig Test*, where new Shell Alvania won an anti-corrosion rating of 10 out of 10.

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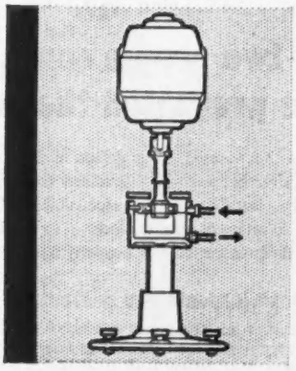
The Research Story

* In the Thornton Wet Bearing Rig Test water was fed through a 20 mm. bore bearing with a special demountable plastic cage (to simplify inspection) charged with the grease under examination to a weighed quantity rotating at 3,000 r.p.m. The rate of supply of water was one gallon per minute, the water running to waste. After 5 hours' operation the bearing was removed and stored horizontally half immersed in water for three days. Anti-corrosion merit ratings were given at the end of the test. High-quality greases without special protectives showed an average rating of 3 out of 10, while new Shell Alvania rated 10 out of 10.



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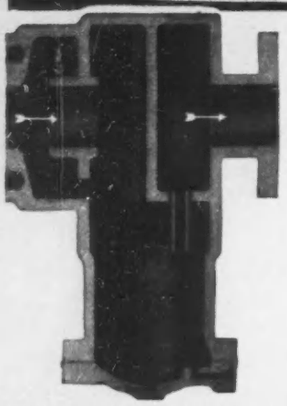

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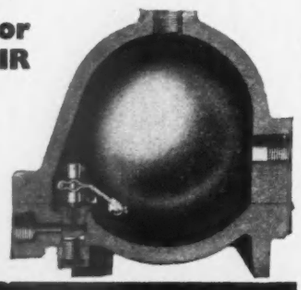

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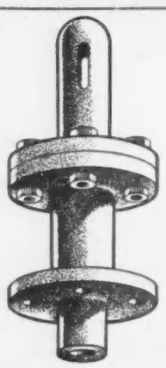

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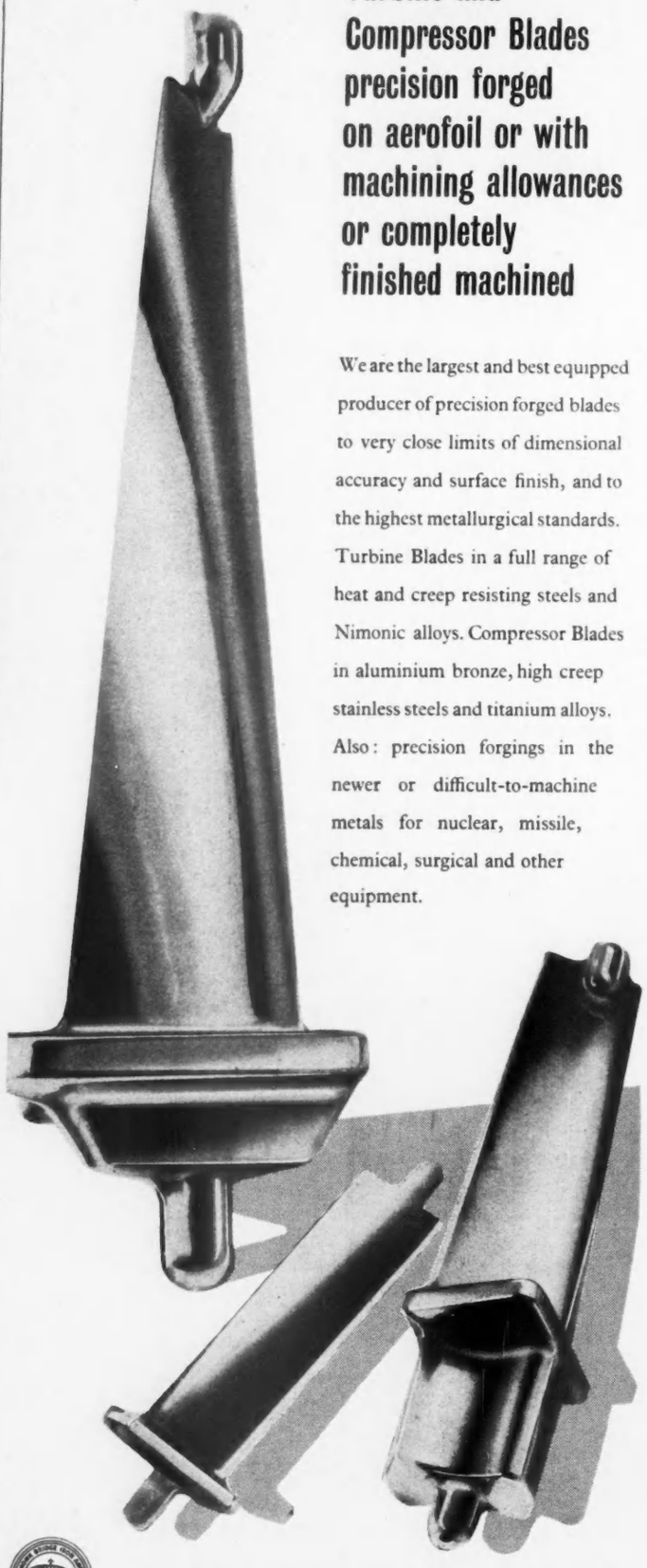

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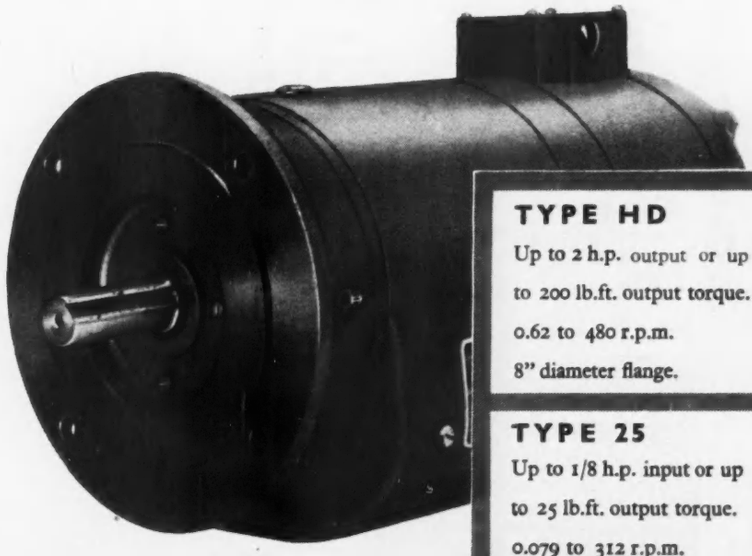

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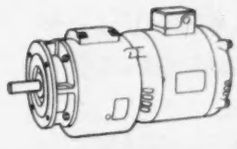

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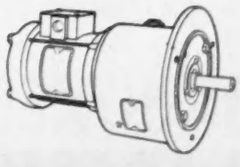

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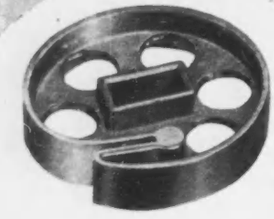

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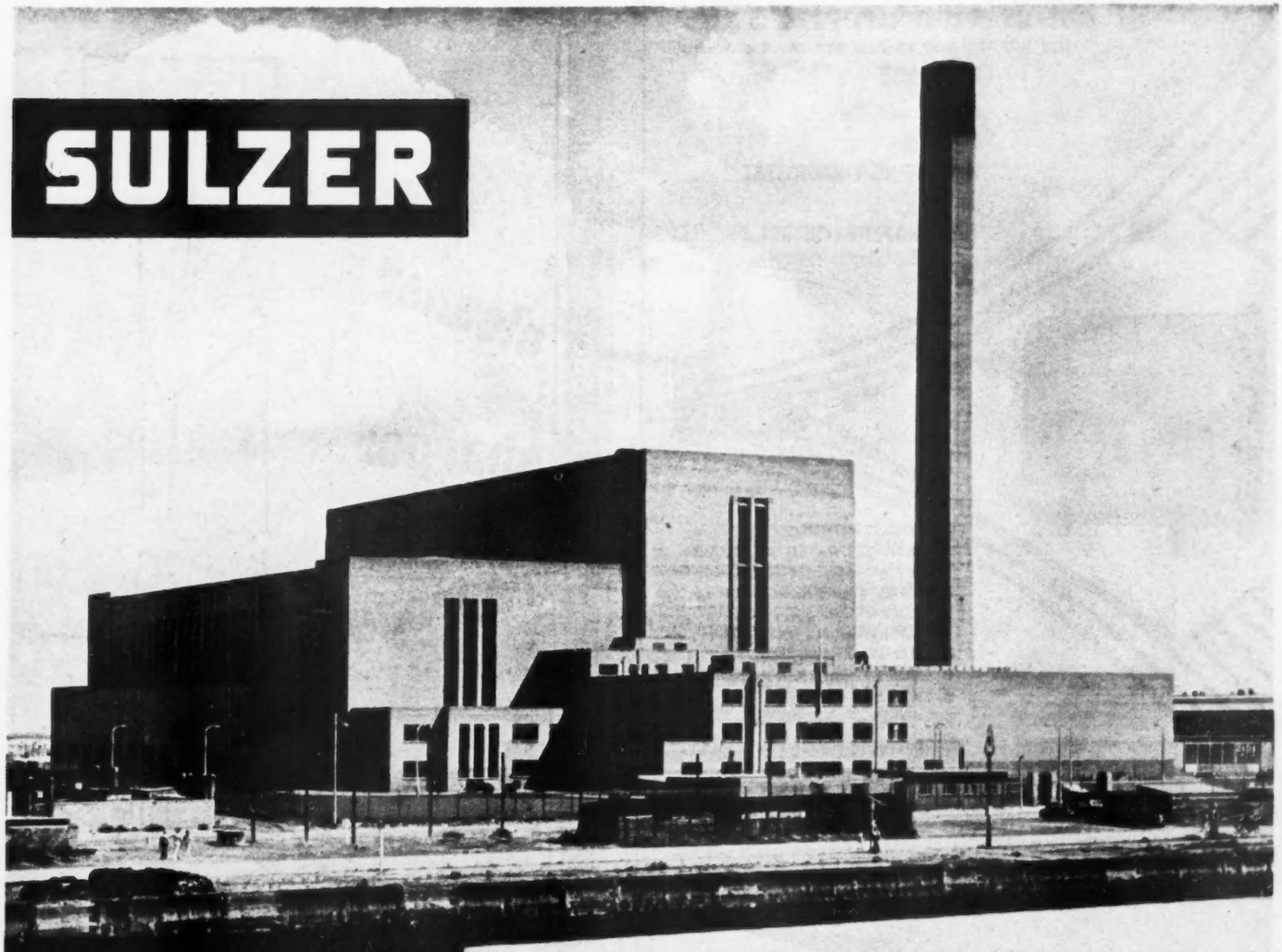

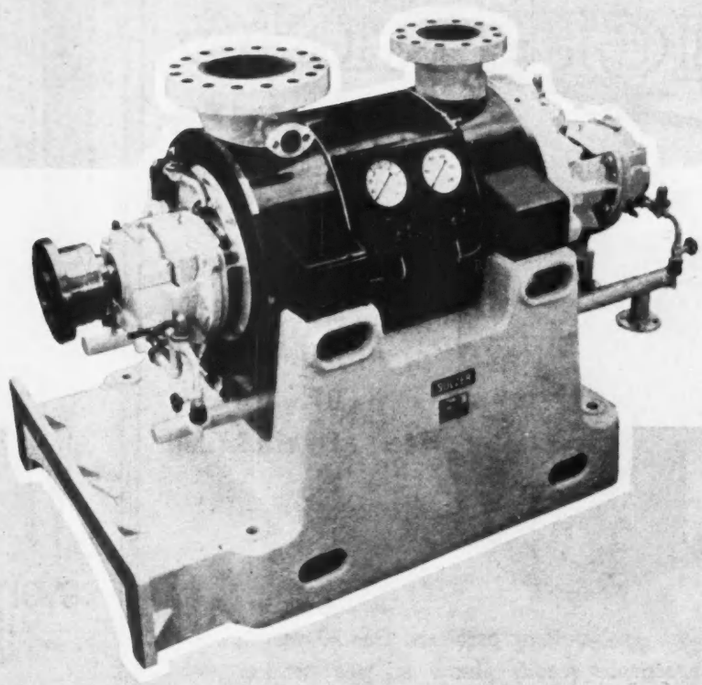

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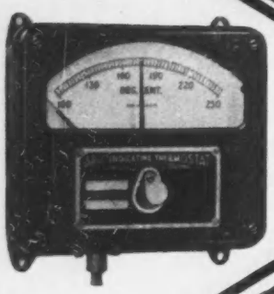

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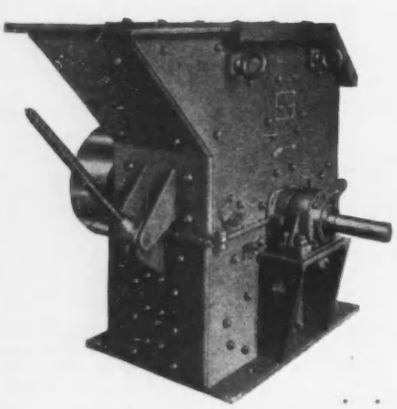

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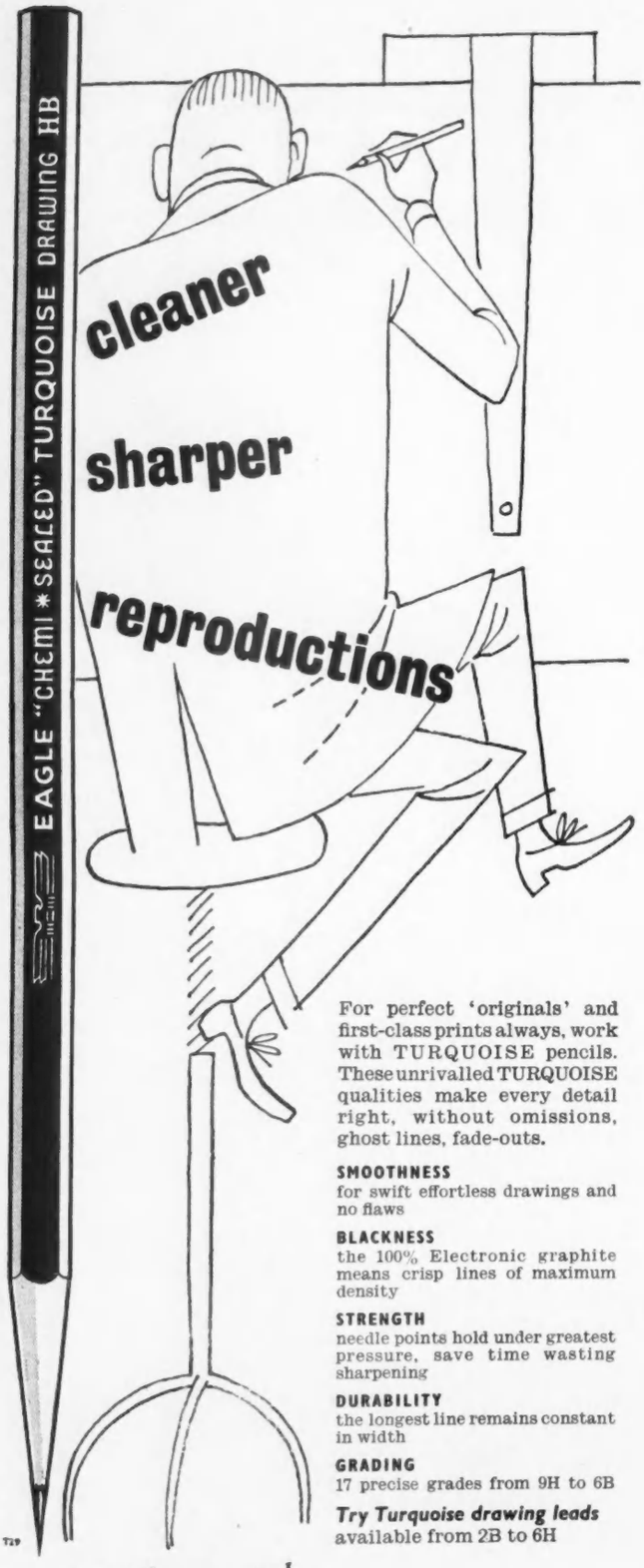

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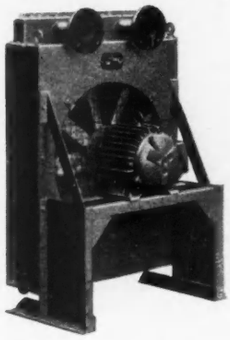

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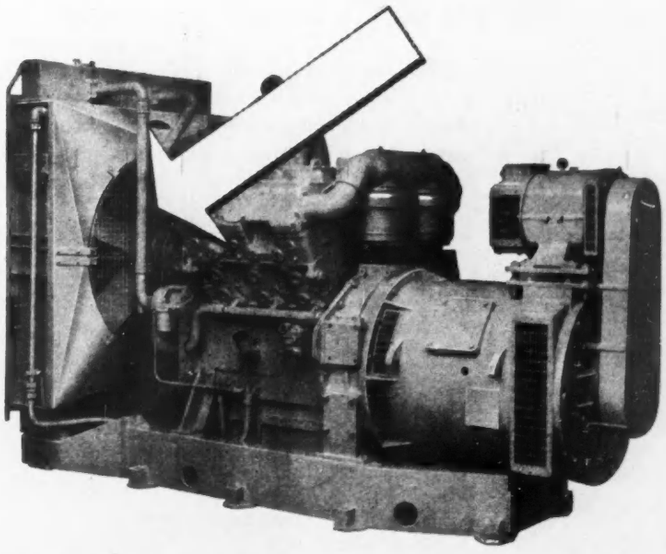

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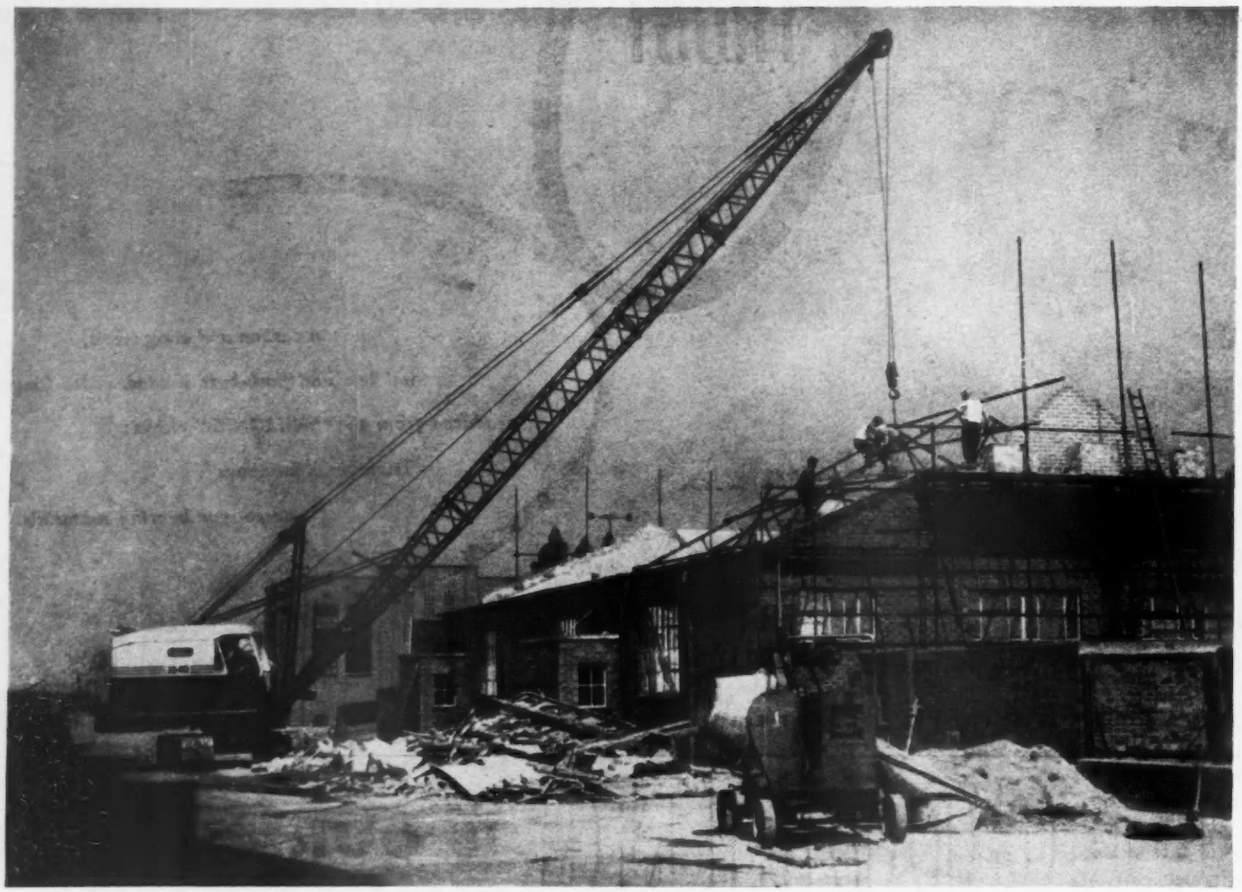

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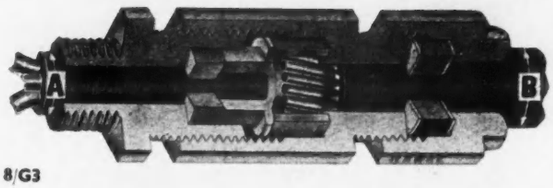

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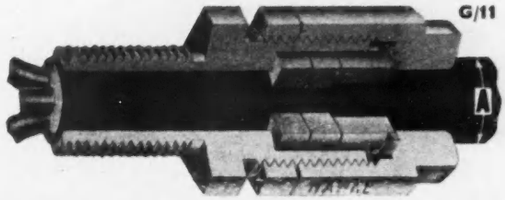

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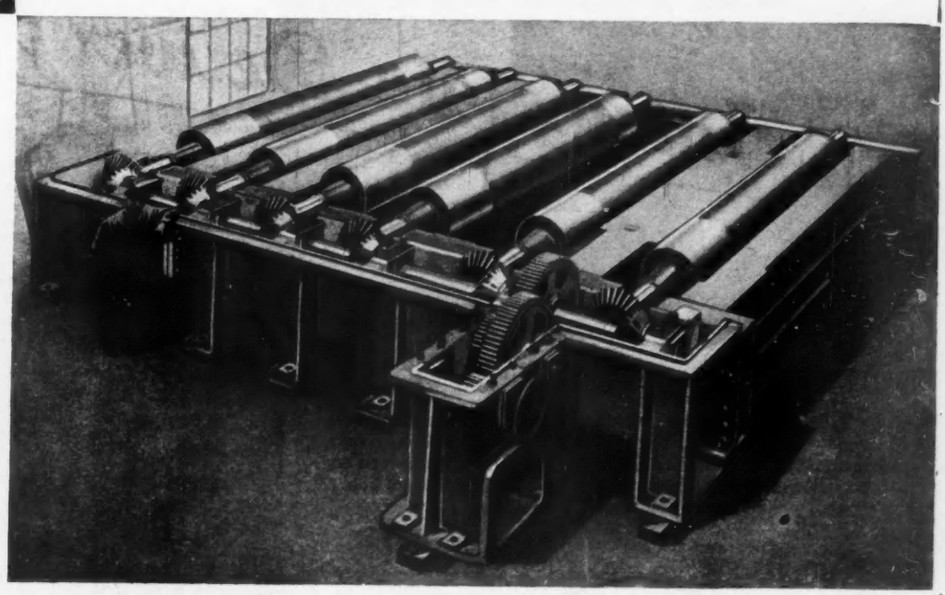

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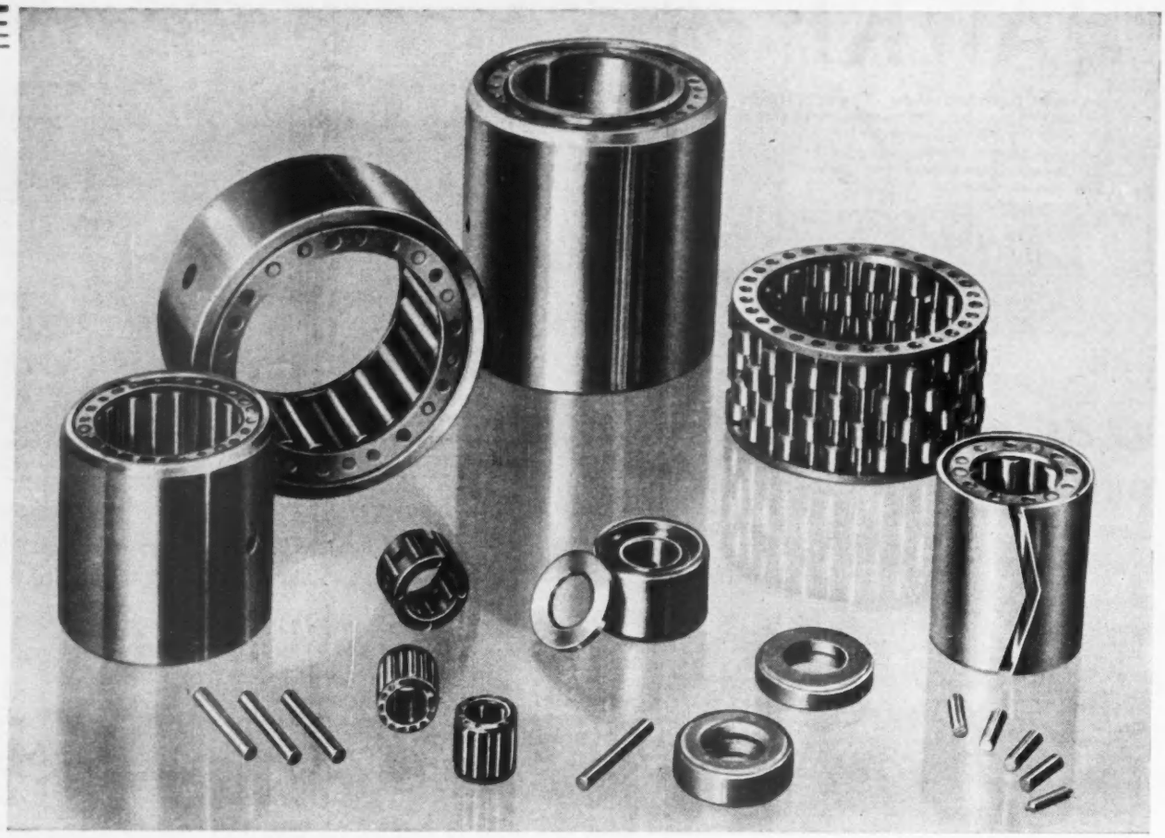

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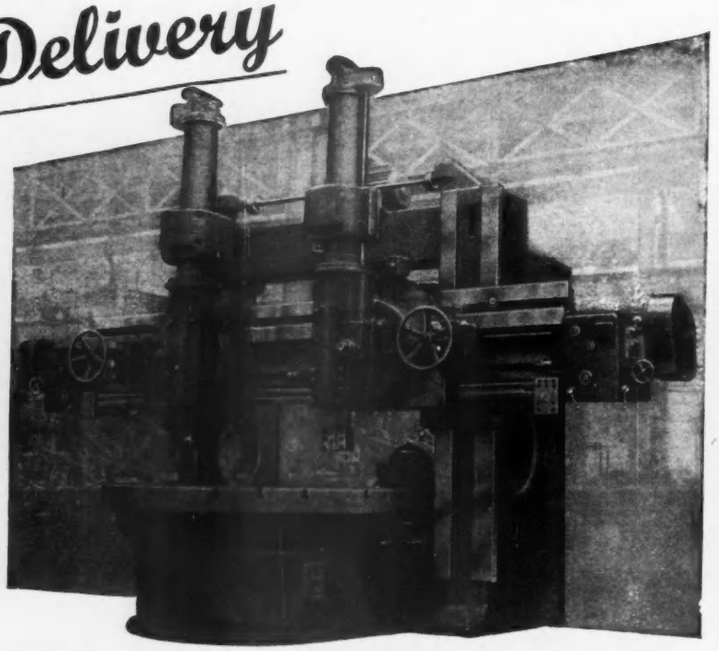

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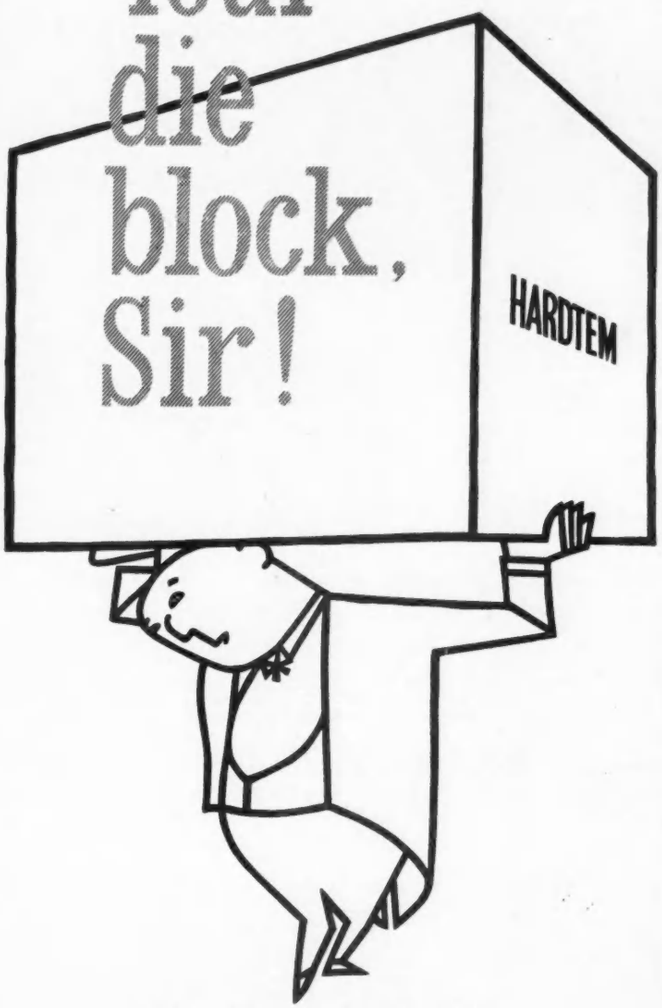

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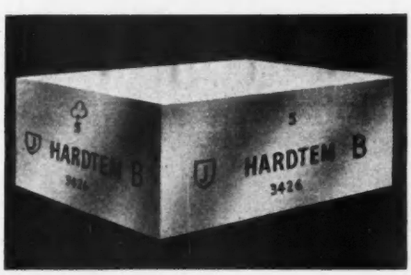

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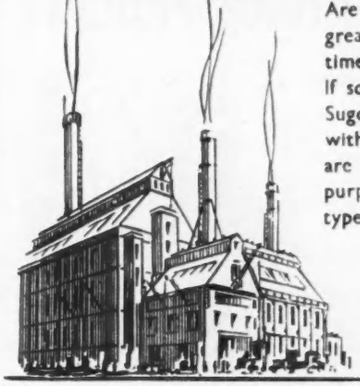

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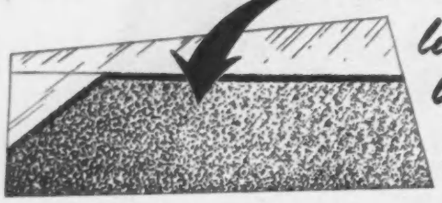

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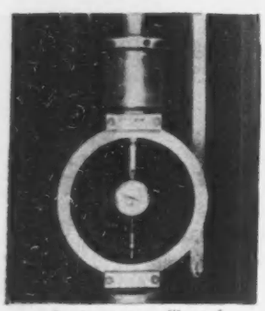

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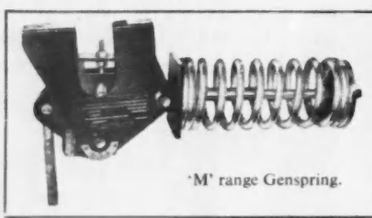

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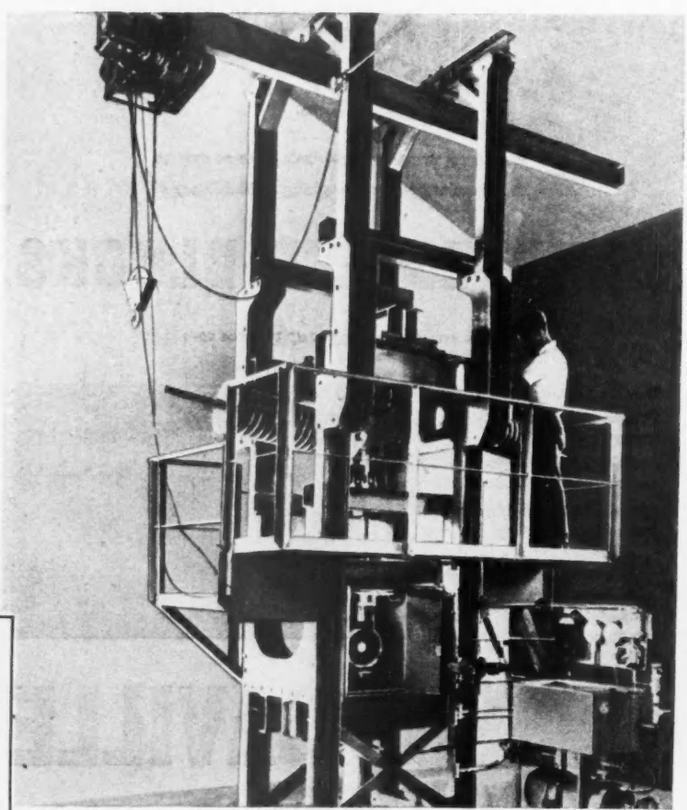

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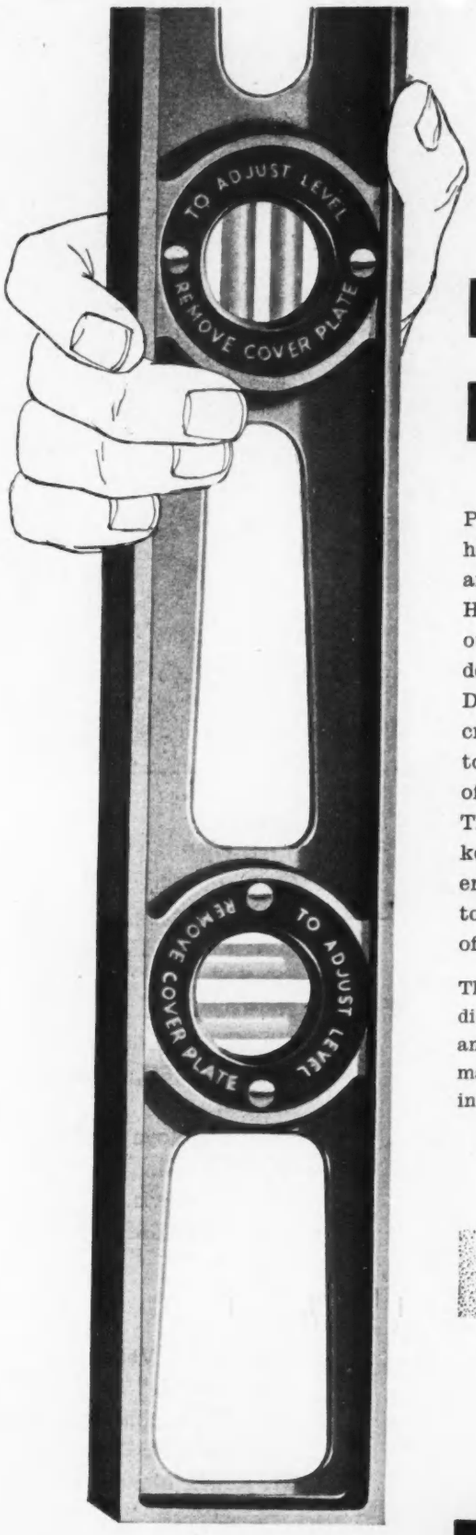

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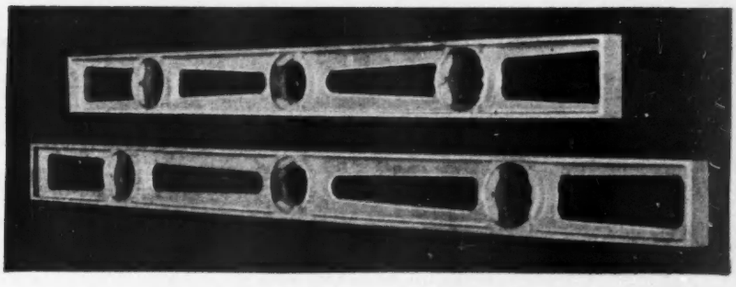

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Gordon Russell Ltd., 1661 West Fifth Avenue, Vancouver 9, B.C. Grams: Rustle.
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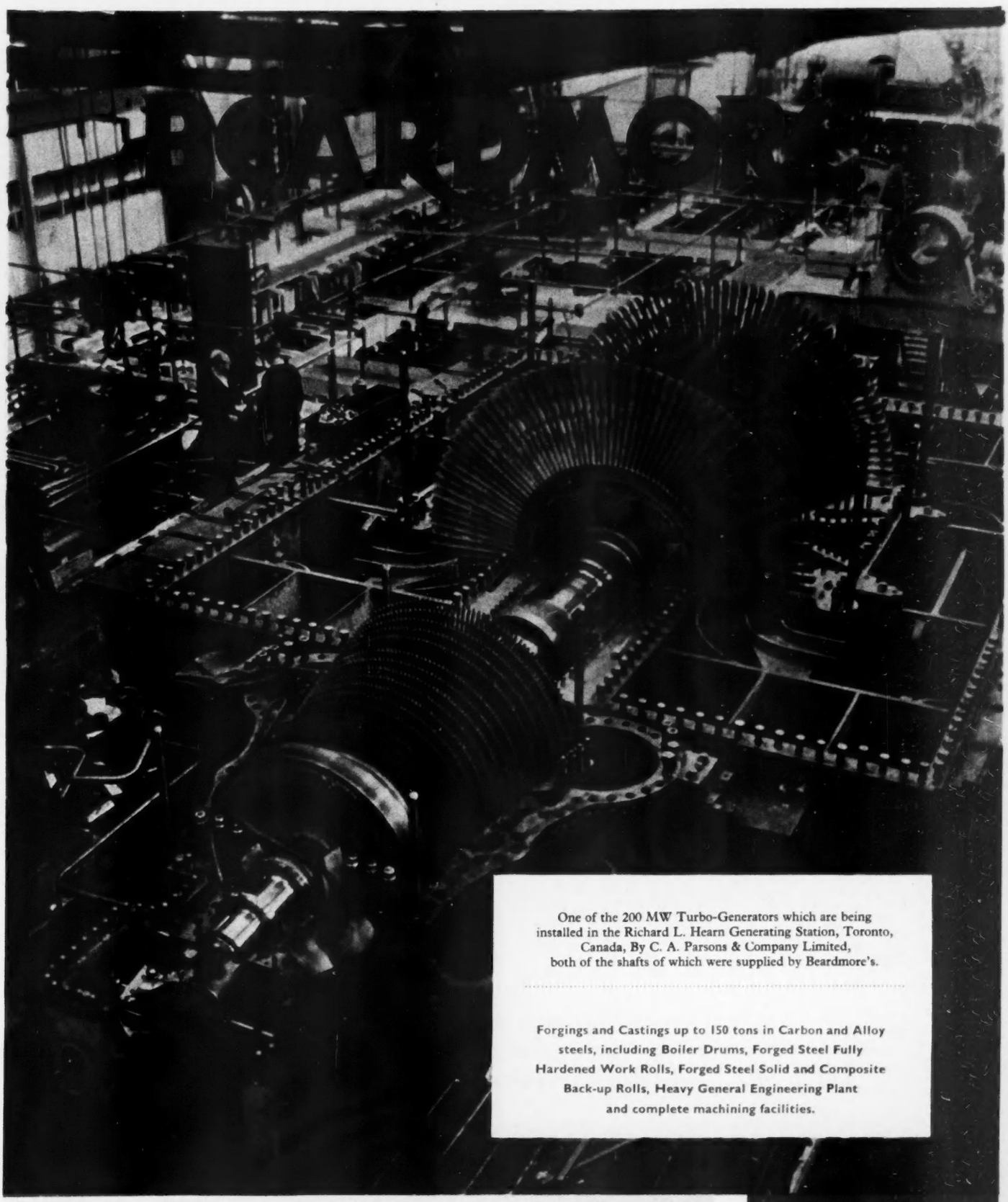

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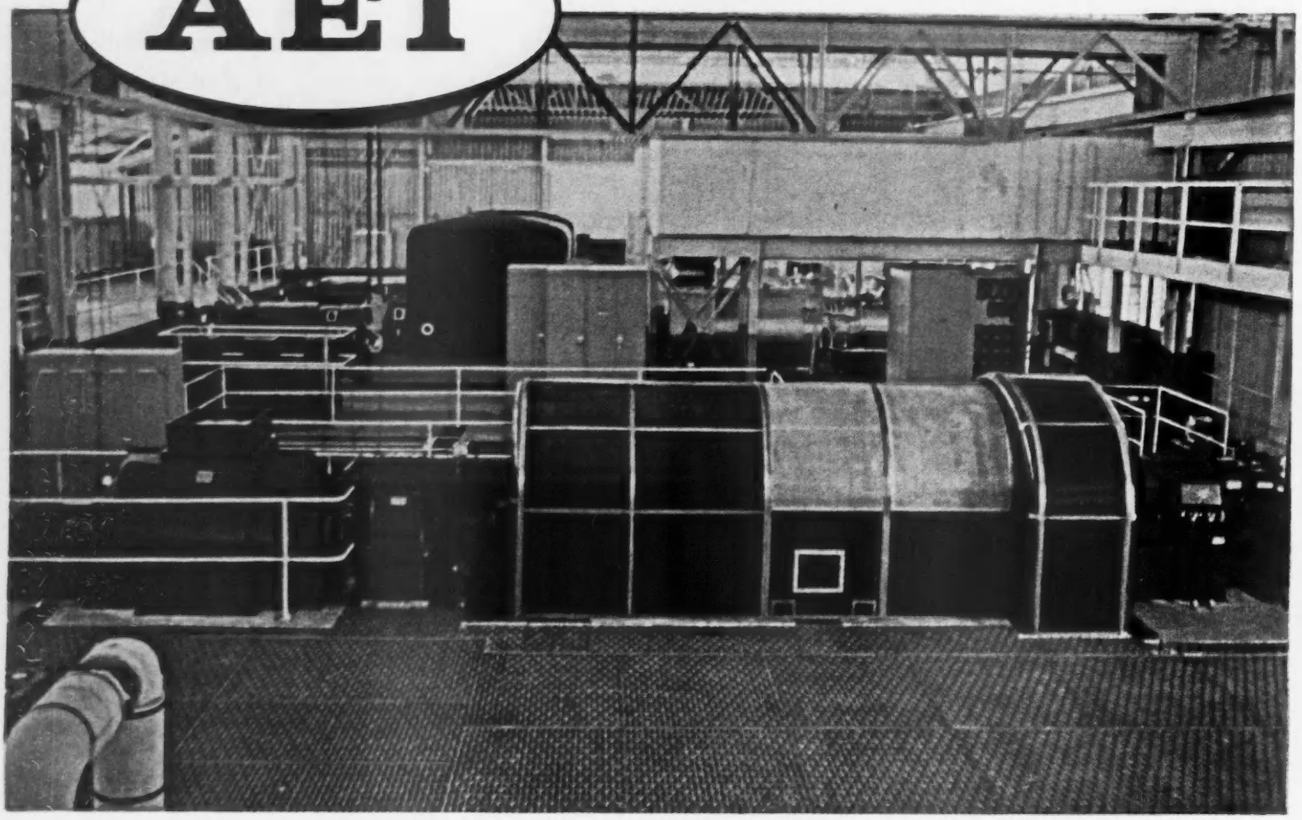

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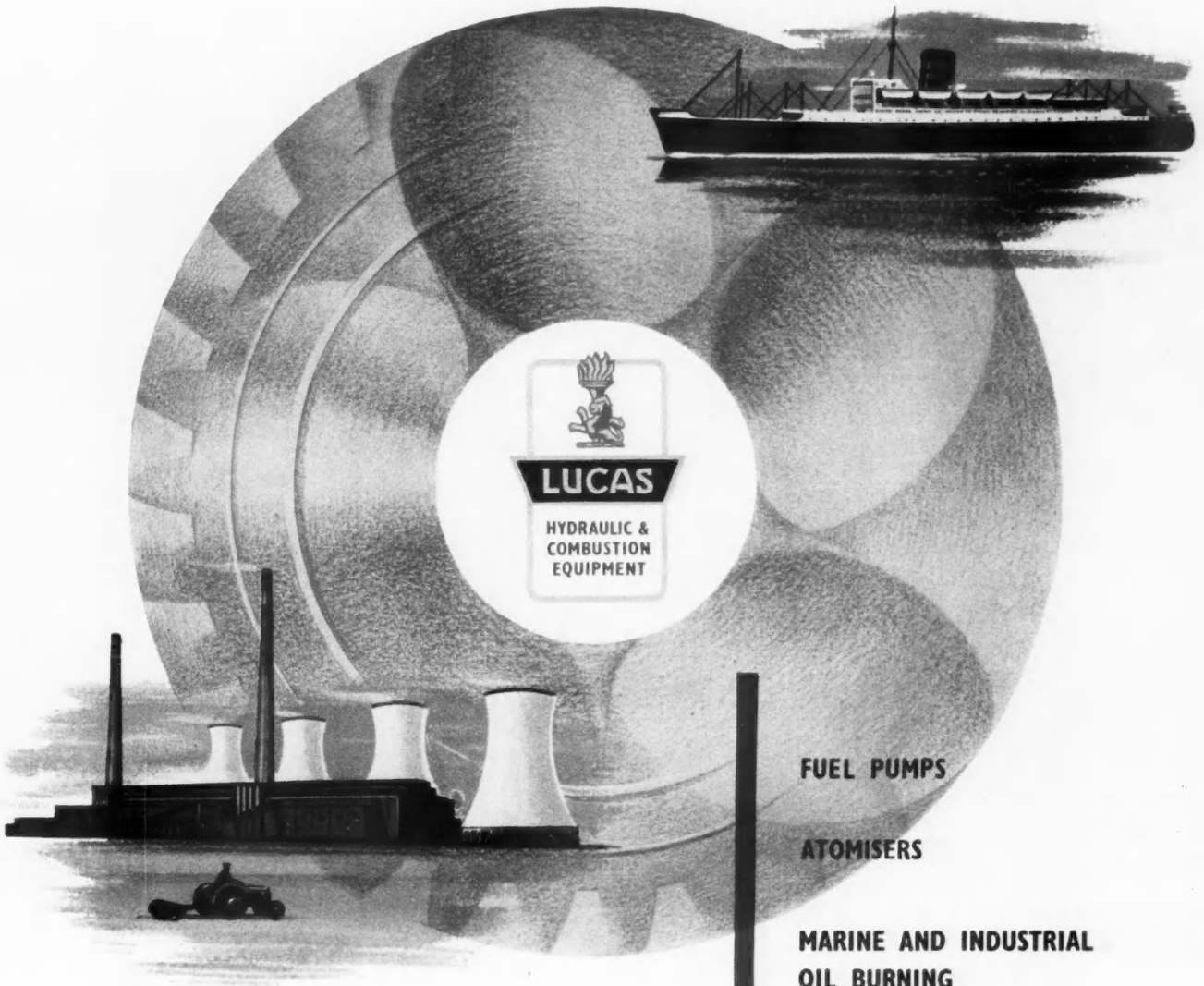

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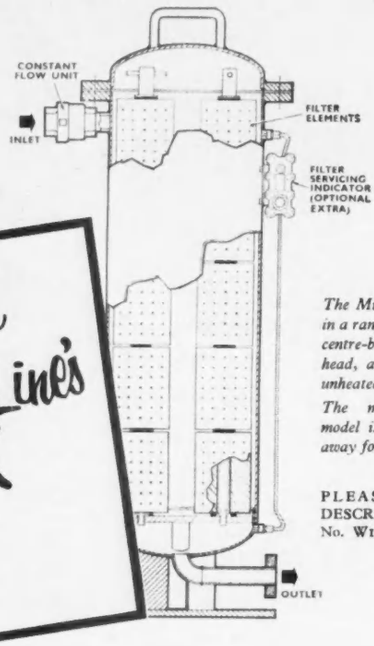

The Micro-Pak is available in a range of capacities, with centre-bolt or multi-bolt head, and either heated or unheated.

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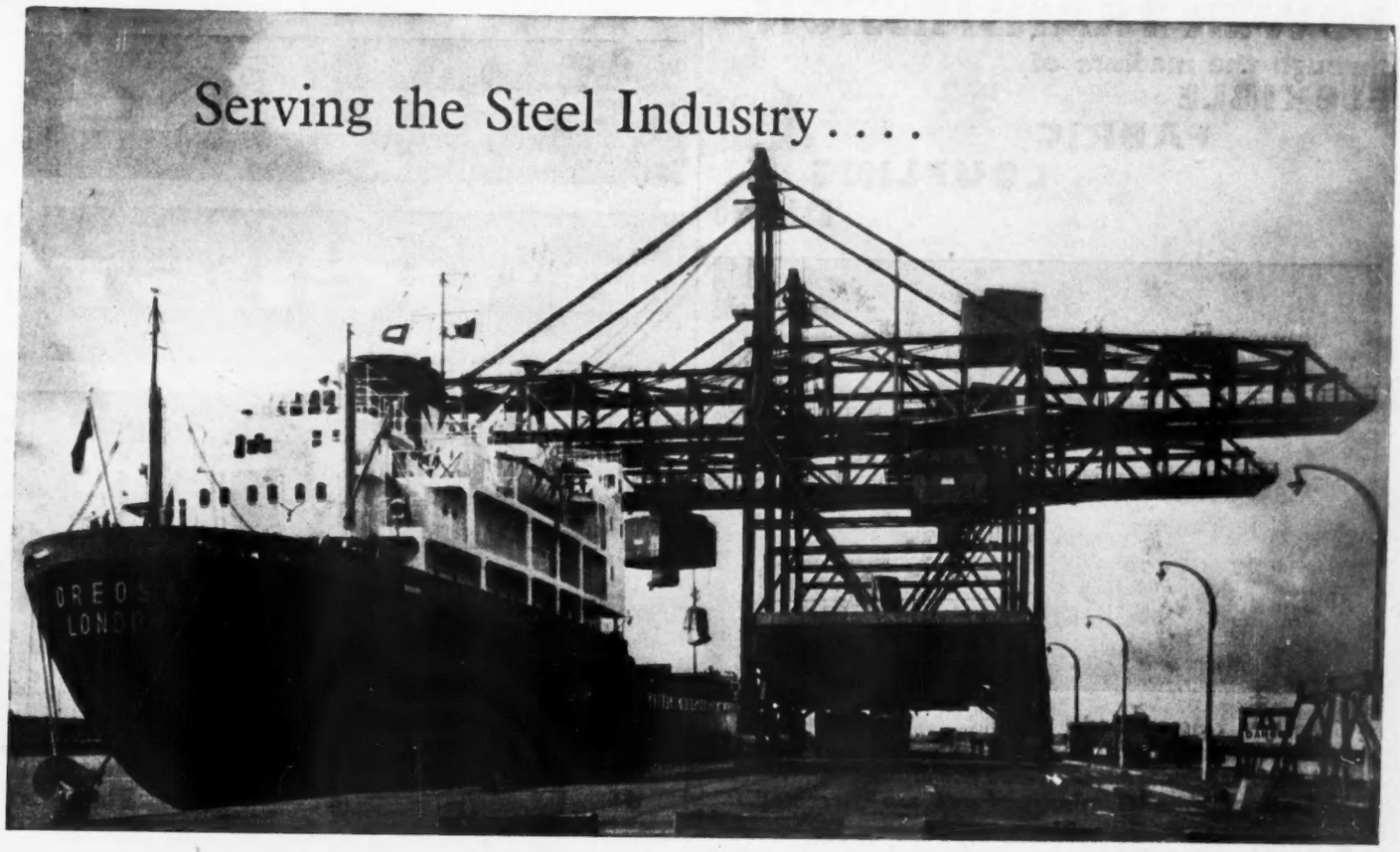

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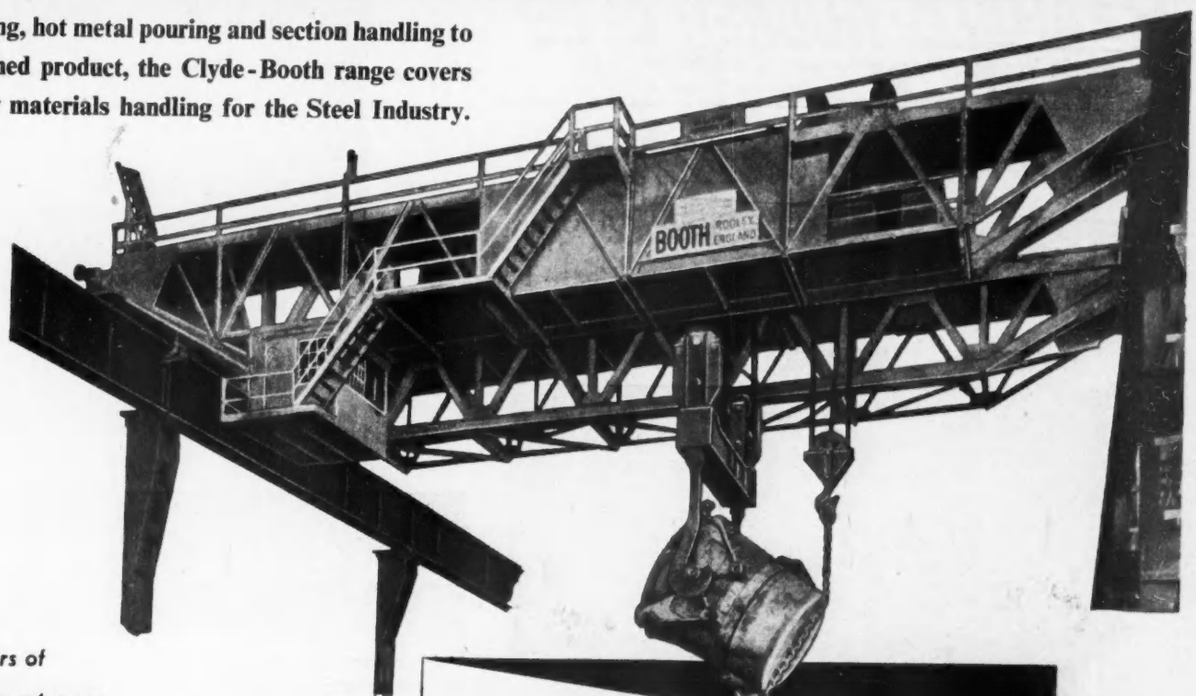

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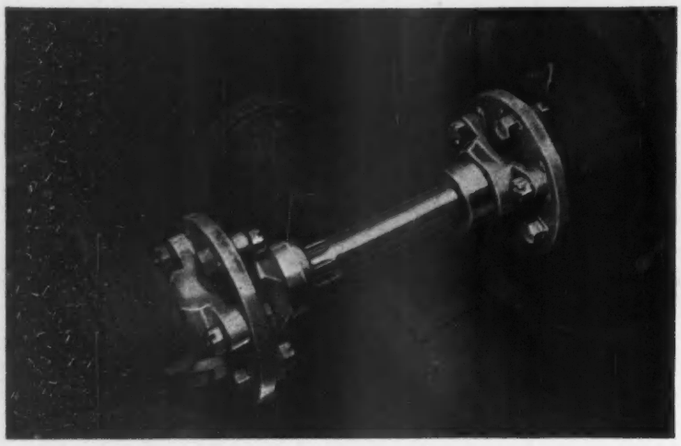

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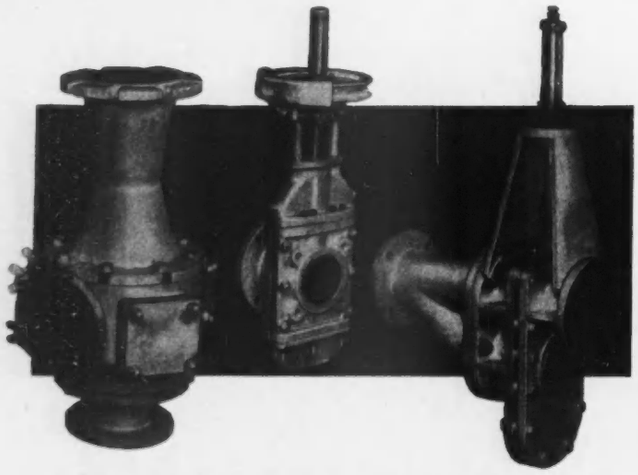

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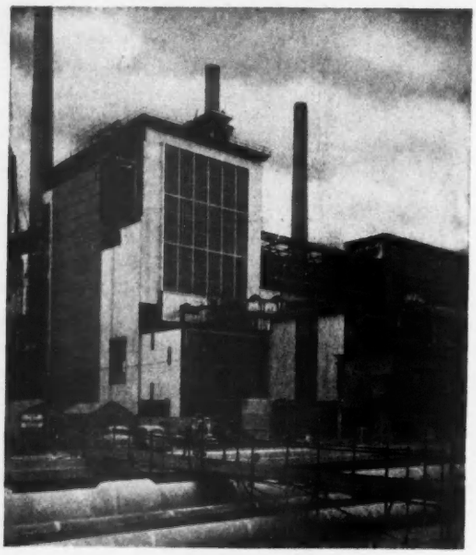

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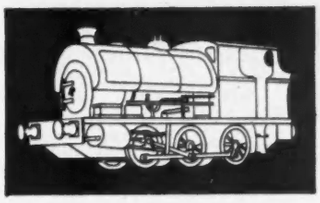

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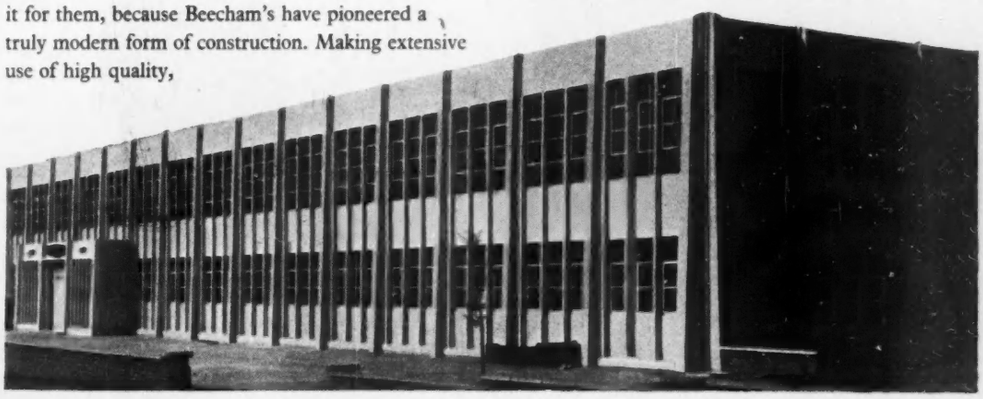
Nortons are one of our many clients who are proud of a Beecham Building. Why not be another progressive company and have Beecham's build a BOLD MODERN BUILDING FOR YOU?



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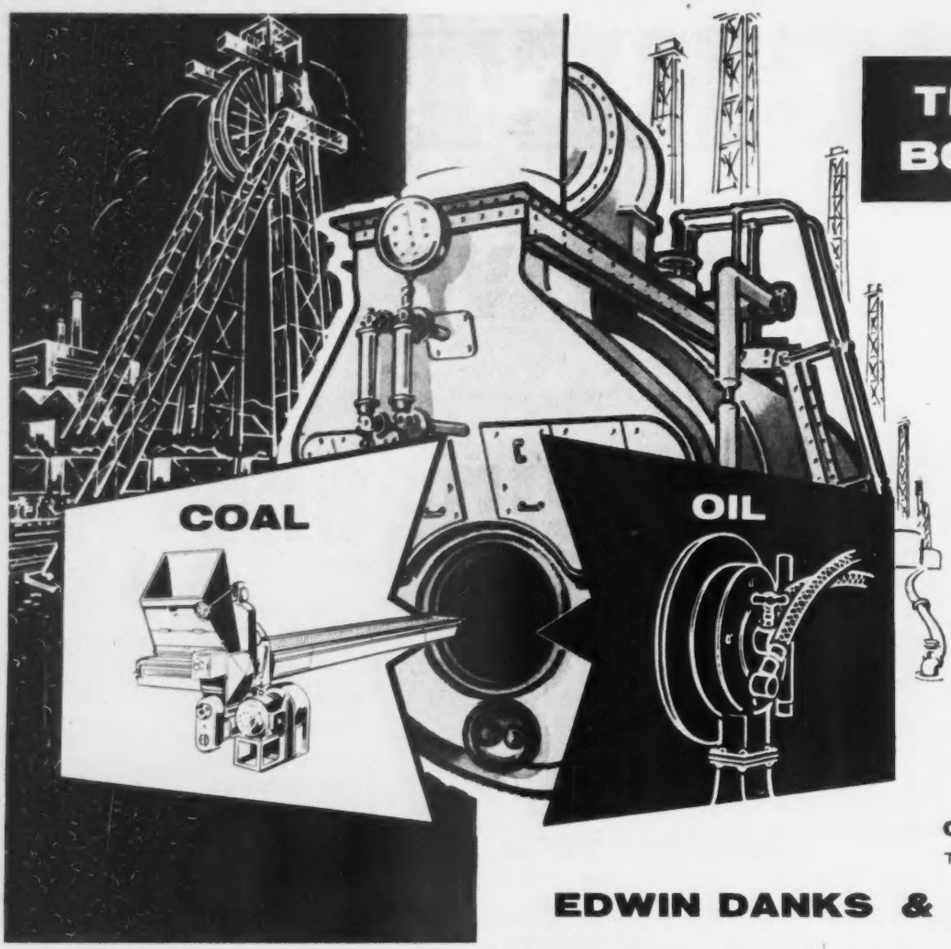

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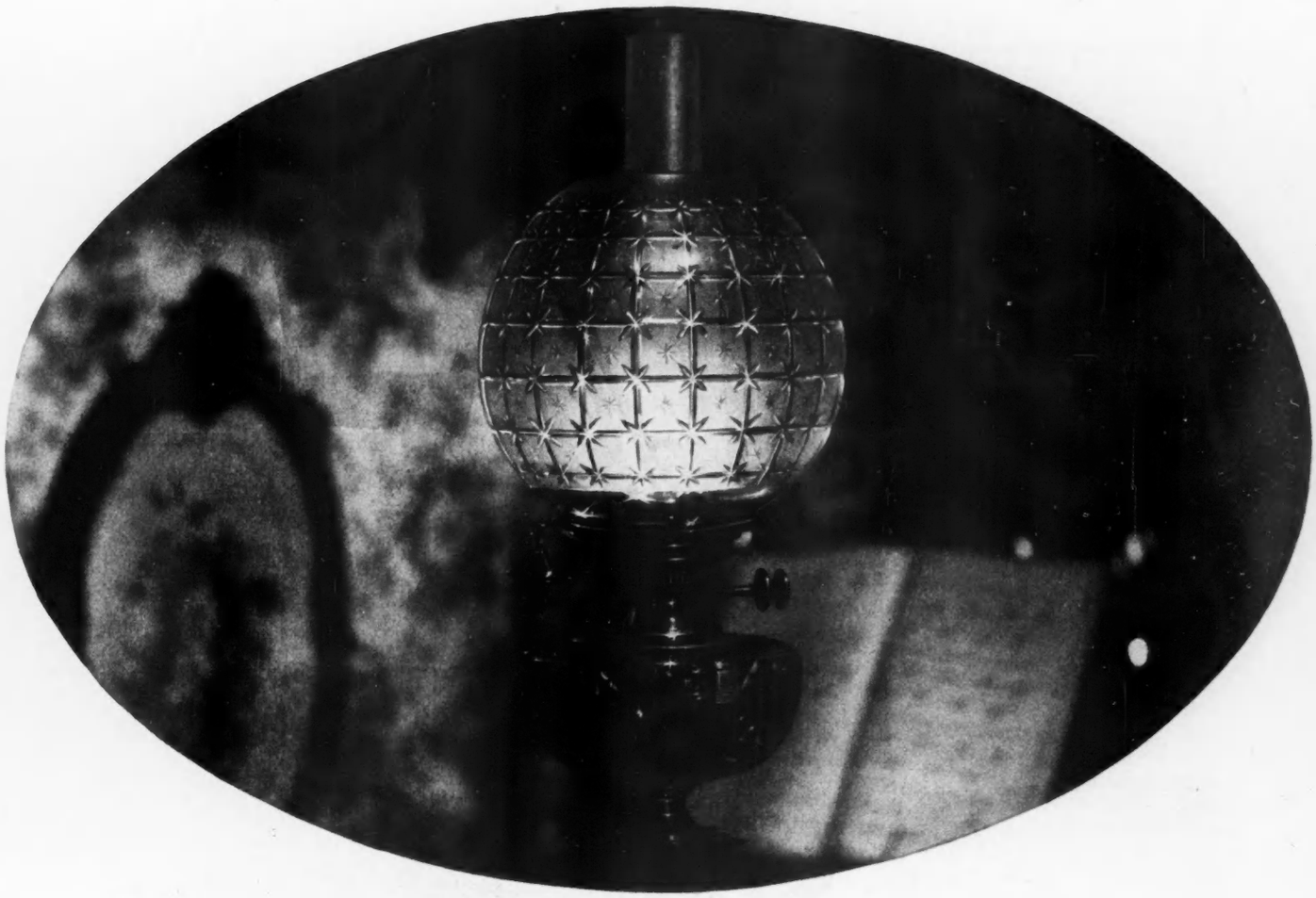

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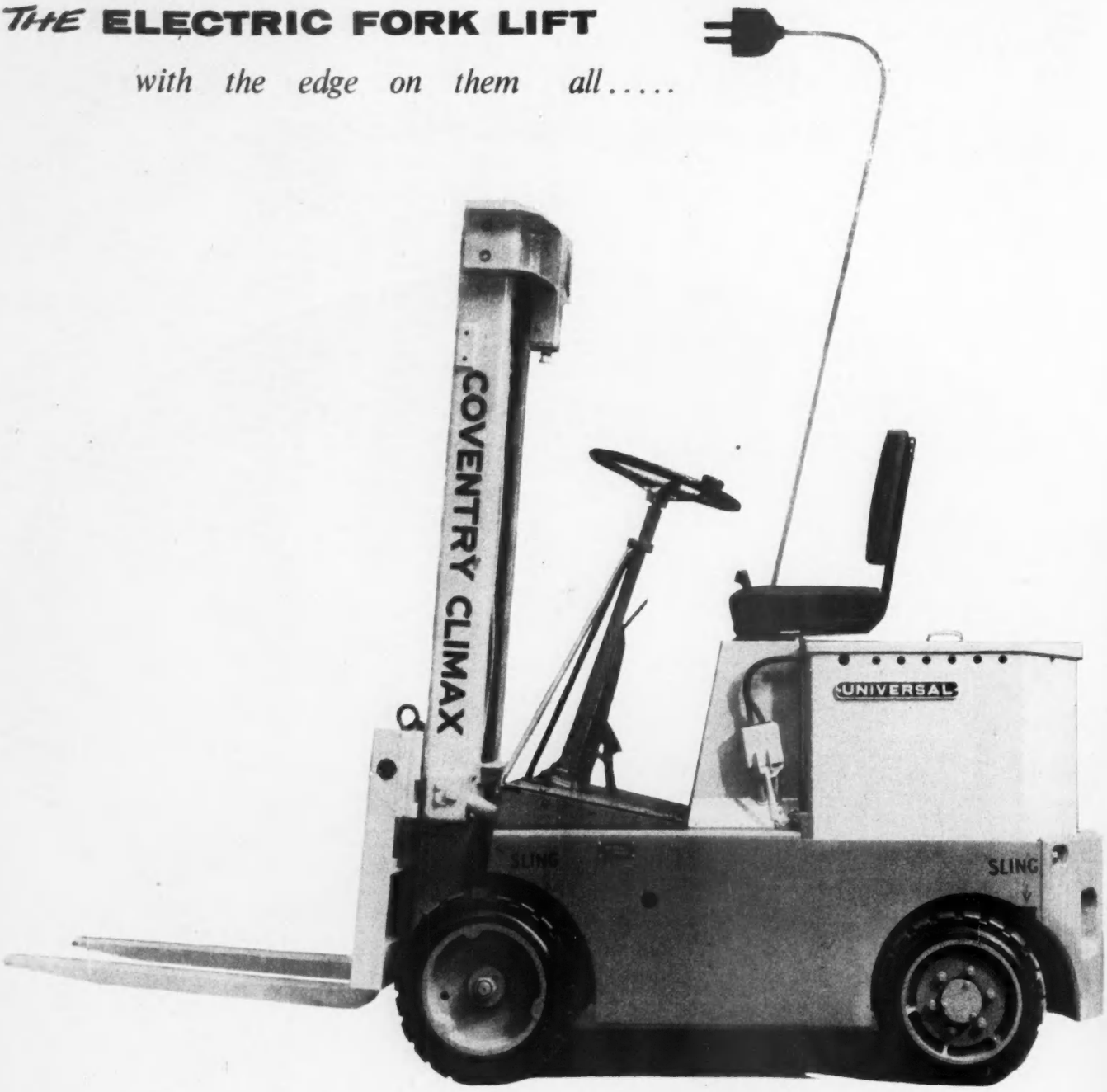

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THE ENGINEER

No. 5407 SEPTEMBER 11, 1959 VOL. 208

FARNBOROUGH—MISSILES

The advertisements for this year's Flying Display and Exhibition of the Society of British Aircraft Constructors direct attention particularly to the subject of missiles. It is very much to be hoped that a great deal of attention is in fact being lavished on this topic, for it is becoming obvious that the thinking which has been followed hitherto must be abandoned. The really remarkable feature of the missile scene is that British production has up to the present concentrated on missiles which add nothing to the offensive power of the fighting services : all those which have reached the stage of readiness for production are either anti-aircraft or anti-tank defensive weapons. A reason for this is not difficult to see : recent years have seen vast increases in the effectiveness of the offensive, and attempts have been made to counter these. But technology to-day has encompassed strategic mobility, the ability to strike anywhere within a theatre of war without delay in moving into position : thus a passive defence, however well served by its reconnaissance arm, requires not merely to be strong everywhere but to be strong everywhere at all times. The answer is, as always, striking power, and it is frightening to find that the weapons contributing to this are so far from readiness : there is no sign of the operational engine for the stand-off bomb, nor of the guidance equipment for " Seacat " with its secondary ship-killing role, while the " Blue Streak " has yet to commence that process of exposing new modes of failure in familiar pieces of equipment which is so characteristic of the ballistic rocket.

It might be considered that in drawing attention to the missiles the Society is displaying a remarkable public spirit, for those that are exhibited are severely tainted with that most pervasive failing, favouring ease of construction rather than fitness for purpose. This is a result which is obviously liable to occur when procurement is predominantly by price, and designers may even be able to convince themselves that they are morally justified in proposing an inexpensive weapon on the grounds that otherwise no order at all would have been placed. The failure of this approach—and it will result in failure, for any weapon other than the best available will incur unnecessary casualties even if the morale of the users is not affected so severely as to lose the contest—often does not show up until the time comes to evolve tactics for employing the weapon. An example that can not be overlooked is the D.H. " Firestreak " missile, which is being deployed in the fighter screens of both the Royal Navy and the Royal Air Force. Assuming this weapon does everything that an infra-red homer can be expected to do (and some such assumption is forced on one, since the only target that could be provided to emulate a contemporary attacker would be a " Bloodhound," and the dangers associated with a damaged unmanned powered aeroplane at a great height have precluded evaluation of the missile), the need to reject spurious heat sources causes its seeker to be confined to internal combustion engine exhausts. (It is too early even to consider its probable performance against a direct cycle nuclear aircraft). This means that a large majority of aircraft can be acquired only from certain directions, most generally from behind ; a further restriction of the same nature is imposed by the need to point the missile at its target for a significant time—a performance hardly to be achieved if it involves stalling the launcher aircraft. Since passive guidance affords no range intelligence, there is no way of knowing that different missiles have been locked on to different targets if those targets are on similar bearings, so that the classical pursuit interception with its desperate demands on early warning, rapid response, and accurate flying is virtually mandatory. This situation becomes alarming when we recall that the Royal Navy is carrying its missile aloft on the D.H. " Sea Vixen ": there is no reason why an attacker should not completely avoid the guided air-to-air missiles by imposing a collision interception upon the subsonic defender. And, it should be recalled, even this unattractive tactical performance is attainable only in a clear sky : it might be said that this is a weapon well suited to defence against the subsonic high-altitude bombers of the Royal Air Force, although the assumed ability to home on a " Blue Steel " may not in fact exist. These limitations should have been apparent to the project engineers, at least if they were not insulated from contact with the user arms, and have outweighed the attractions of simplicity and cheapness of the passive homer, which virtues in any case become less obvious when the very real problems of fusing are considered. Infra-red guidance will do many things electromagnetic systems cannot attempt—as the revelation of a from-the-shoulder anti-aircraft guided missile, based on the assumption that when an aircraft flies low over troops some at least of the weapons will be well placed to engage it, has demonstrated—but to treat it as a cheap substitute for active homing is to invite disaster.

It should be remembered that it is in the field of missiles that the most important opportunities, and challenges, for British industry exist, for this country has chosen to deny itself the classical tools for many operational roles. We may, perhaps, repeat our observation of a year ago, that the Royal Navy is badly in need of a ship-killing missile : with no plans yet made to replace the present heavy ships of last-war origin, there will obviously arise a need to increase the effectiveness of their weapons, particularly (because of the risk that is being taken that battle will be given to numerically superior forces) in respect of range. The Royal Air Force will very soon be in need of a reconnaissance vehicle, for the " Swift," while able no doubt to penetrate the defences of this country, has not the range to monitor modern bombard-

ment missiles. Both these missions spring primarily from the peculiar composition of the British forces, but once the weapons to perform them have been evolved it can confidently be predicted that foreign services would be interested either in cutting down the cost of warships or in reducing the wastage of highly skilled pilots, so that developing them would prove a worth-while contribution to the strength of the Western powers. It is critically necessary that the missile engineers should not follow in the footsteps of the aircraft builders and content themselves with designing for performances that have already been demonstrated, but should concentrate on the requirements of to-morrow to the exclusion of those of to-day. We dread to see a native manufacturer interesting himself in the need to prevent this country being overflown low down by all-weather attack aircraft when N.A.T.O. production of the Homing All the Way Killer is so far advanced.

AIRCRAFT UNDERCARRIAGES—DESIGN FOR IMPROVEMENT OR A NEW APPROACH?

The undercarriage of the modern aircraft accounts for a small but significant fraction of the all-up weight, approximately 3 to 4 per cent. Taking an aircraft of 150,000 lb to 155,000 lb all-up weight, 5500 lb approximately has to be carried about merely to support it during landing and take-off and when on the ground. It does not sound very serious. But the total paying load of a craft of this size—after all the items have been put on for the comfort of passengers—is only 13,200 lb to 16,000 lb. Compare this figure with the total weight of the undercarriages and a very different impression is created! How obviously valuable it would be could undercarriage weights be reduced. Furthermore, undercarriage faults are the cause of frequent late departures and aborted flights, which incur much unfavourable publicity. They are responsible for a considerable part of the total maintenance costs of the craft, from 5 to 6 per cent according to how good is the design—whether simple or complicated. The total life of tyres, which cost £20 to £50, small or large, is very low; even on a propeller aircraft such as the "Britannia" 312, main wheel tyres last only 150 landings and nose wheel tyres thirty-six, and the former figure is one of the best achieved. Main wheel tyres are running to three remoulds on foreign tyres and four on British, but the total life is 750 to 800 landings at most. Very little life is got from braking pads—this item is the cause of much maintenance and repair work. Another trouble is brake disc distortion; this distortion causes severe disc binding. Nor do the brakes dissipate the energy; they dump it into a heat sink provided by the discs (it is now proposed to fit a fan to cool the discs) and, of course, this means more weight and loss of paying load—usually in the region of 47 lb to 50 lb per brake. Only recently a "Comet" was damaged and forced to land because the pilot did not wait sufficiently long for his brakes to cool off after an emergency stop. This is exactly what happens with large aeroplanes when doing landings and take-offs under pilot training or passing out; flying round for something like twenty minutes to cool brakes is an expensive business, to say the least, before attempting another landing! The designer who studies tyre impact loading to runways will be blessed indeed, as this factor is the all-important one in costs to governments. How many give much weight to this factor, however?

When we surveyed the growth of this parasite upon the airframe in a series of articles in late 1953, the obvious escape from the limitations it imposed seemed to be the flying boat, for in those days the turbo-prop plant promised ample power for take-off. But the trend of air transport is settled by conditions in the continental United States of America and in the hinterland of Europe, rather than amongst the scattered territories of the Commonwealth, and all the important sources of traffic now have airports with runways. These runways, however, are so expensive that they are few in number, leading to long delays in holding stacks, or diversions of aircraft to distant alternates; and the fuel reserves demanded threaten to become prohibitive for the high performance machines towards which long-range designs are tending. Aircraft are already runway limited to such an extent that take-off monitors, to give the pilot the earliest warning of the need to stop, and overshoot barriers, with water squeezers as energy sinks, are making their appearance. The severity of the problems introduced by the need to "grease on" to the runway a fast-moving aircraft with limited acceleration and finite response times was illuminated in a most valuable way at the symposium on "Problems of Take-Off and Landing," held by the Commonwealth Advisory Aeronautical Research Council at the Royal Aeronautical Society last week. Engineers have shown that machines can be built to perform the landing more accurately than can the human pilot—and the most emphatic message from this meeting was that the aircraft flying to-day demand the utmost from their crews—but the reliability needed from such devices is so extreme that even to demonstrate it would be extraordinarily difficult. And the use of automatic landing monitored by the pilot is by no means unquestionably the right way to employ a human being: he is now being faced, not with a succession of minor decisions, but one of great gravity—"Do I take over?"—and he is liable to be asked, nay, forced, to tackle a landing more difficult than human pilots perform at present after having been robbed of many, if not all, opportunities to practise the exercise. When one studies the human problems, the aerodrome problems, the aircraft problems, and the instrument problems, one cannot fail to notice that one very powerful agency, namely, the aircraft installed power, is being left idle, or at least held in reserve, during the critical approach and landing phase, and thus a new concept intended, logically enough, to avoid rather than solve these problems has appeared, the application of powered lift to give vertical take-off and landing. For high-speed aircraft jet lift is proposed, provided either by the main propulsion engines running on reheat; by separate lifting engines of a (small) size corresponding to optimum thrust/weight ratio; or, particularly for machines with jet flaps or similar devices needing vast quantities of air, by auxiliary nozzles with combustors. Such aircraft would almost certainly allow all-weather operation and eliminate delays imposed by saturation of the air traffic control near terminals, but their shortcomings are equally clear; the noise is likely to be both intense and sustained, and the machine is going to be the answer to an engine manufacturer's, rather than an operator's, prayer! Vertical landing, however, can be regarded as a commercial proposition in view of the extreme cost of diversion from the intended destination; long-range machines land at around half their take-off weight, and since ground effect, if favourable, can be depended upon when descending, the forces needed are no longer formidably greater than the thrust for level flight. But although the very severe heavy landing case would thus be avoided, the original object of our study, eliminating the egregious undercarriage, has still eluded us, while with the need for docile handling in a glide eliminated, take-off speeds will doubtless rise as wing area and $C_{L_{max}}$ are reduced in search of cruise

economy. As Dr. Lachmann pointed out in the symposium, boundary layer control is not a direct answer here, since as well as reducing the drag at landing, it costs thrust at take-off.

The exciting prospect of a successor to the wheel was, however, glimpsed last year at the Research and Engineering Centre of the Ford Motor Company at Dearborn, when Andrew A. Kucher, vice-president for engineering, demonstrated that the principle of moving vehicles upon air bearings, which he proposed thirty years before, had been reduced to practice. The recent discovery that a "levapad" could be given a stable dynamic lift/height characteristic by including a suitably sized cushion volume downstream of the throttling orifice had allowed the construction of model "Glideair" vehicles running frictionlessly over reasonably smooth surfaces. While this principle becomes worth while for surface vehicles only at high speeds, since about 50 h.p. per ton are required for levitation alone, it perfectly complements the turbojet airliner, which has large installed power but no "transmission" to help it overcome rolling resistance before flying speed is attained. Certainly the wheels used for taxying and manœuvring on the ground must carry enough of the weight at the start of the ground run to allow the engines to be run up against the brakes and to give stability until aerodynamic forces assert themselves. But quite clearly there is to be had a valuable reduction in the take-off distance ; and this reduction is being made where it matters most—in the runway consumed before the pilot makes the decision to go or not go, at which stage the wheels would normally be retracted, so that the aircraft climbs out "clean." The "fixed but movable" undercarriage of the Short S.C.1 gives a hint at a favourable geometry, with three wheels acting as outriggers for a "levapad" under the centre of gravity. There is raised, of course, in a far fiercer form the problem of the rejected take-off, since there would be brakes only for parking and, since landing is intended to be vertical, probably no reverse thrust. But since the runways will presumably be shared with conventional aircraft there may well be overshoot barriers installed and, if not, there remains the emergency measure of cutting off the air and letting the "levapad" become a skid. The justification for adding the "levapad" is that it allows the suspension to be designed for taxying speeds, and not to support the machine up to, quite probably, 150 knots. Although the "levapad" will have to tilt as the nose lifts, and be extended some distance below the hull, it should prove substantially simpler than a bogie to do the same work—and smaller, too, when we contemplate the "Conway" of to-day with air at 200 lb per square inch available from the h.p. compressor.

HYDRAULICS RESEARCH

Publication of the D.S.I.R.'s eleventh annual report on research in hydraulics* draws attention once again to the variety of very practical problems about which the Hydraulics Research Station is consulted. This work, as described in the report, includes, for example, investigations into silting and such-like problems in harbours, spillway design in hydro-electric schemes, and hydraulic problems in siting thermal or nuclear power stations. Most of these researches are carried out on a repayment basis, but in addition about a quarter of the station's work is devoted to pure research into the fundamental processes of fluid flow and the transport of sediment.

A major research which contributed substantially to establishing the station's high reputation was that into the regimen of the Thames estuary. Some work is still in progress on problems in the Thames, but the major results were published two years ago. Since then other advances have been achieved, there being two examples of particular note recorded in the 1958 report. Investigations into the flood frequencies to be expected on the Rivers Wandle and Ravensbourne (two small tributaries of the Thames) after the construction of certain improvements involved the application of unit hydrograph theory, the final calculations being carried out by computer. This work is reported more fully in a paper by J. E. Nash in the July issue of the *Proceedings* of the Institution of Civil Engineers ; it is believed to be the first investigation of its kind carried out in this country.

Secondly, a model investigation of the formation and maintenance of a dredged shipping channel in the approaches to the River Tees is believed to be an equally original scientific study, since a major factor involved is the effect of littoral drift and the movement of coastal sediment. It is expected that some of the results of this study may be of general application and may arouse widespread interest. In parallel with this, it is pointed out that basic research into coastal erosion has not yet yielded results of practical value, but it will now be supplemented by studies of the performance of selected coast protection schemes.

* *Hydraulics Research*, 1958, H.M. Stationery Office. Price 5s. 6d.

The Engineer—100 Years Ago (SEPTEMBER 9, 1859)

"THE GREAT EASTERN"

"The great ship has left the port of London. It required some skilful manœuvring to get out of the river, but this was accomplished without accident, and she may be said to be fairly at sea. The present interest in this great marvel of constructive skill is that chiefly of anticipation. We all know what she is ; her dimensions are perhaps more familiar to the majority of our readers than are those of St. Paul's. The public have left unexplored no element of novelty or grandeur in this vast palace of the deep, and have satisfied themselves that, in most respects other than in her enormous size, her double skin, and her triple means of propulsion, she is much the same as are other steam vessels. The questions now are, what will she do and what will be done with her ? We have only to wait to know all . . . .

"At the last hour before going to press we learn that the Great Eastern, with a draught of 21ft. 10in. aft, and 22ft. 3in. forward, being 5in. by the head, made the run from the Lower Hope Point to the Nore Light, a distance of 15 statute miles in 58 minutes, the pressure of steam being under 17 lb. per inch, the paddles which are not, at the present draught of the vessel, sufficiently immersed, making less than 9 turns per minute, and the screw, the blades of which at present rise 4ft. above the water, making only 27 turns. At sea, the Great Eastern is intended to work at 25 lb. of steam, the paddles going 14 revolutions and the screw 53. A speed of 18 or 19 miles an hour, even in her present trim, appears almost certain."

S.B.A.C. Flying Display and Exhibition, 1959

No. I

The twentieth Flying Display and Exhibition of the Society of British Aircraft Constructors is open to the public at Farnborough Aerodrome to-day, to-morrow and Sunday. We commence our account of the event with a discussion of the aircraft flown on Monday.

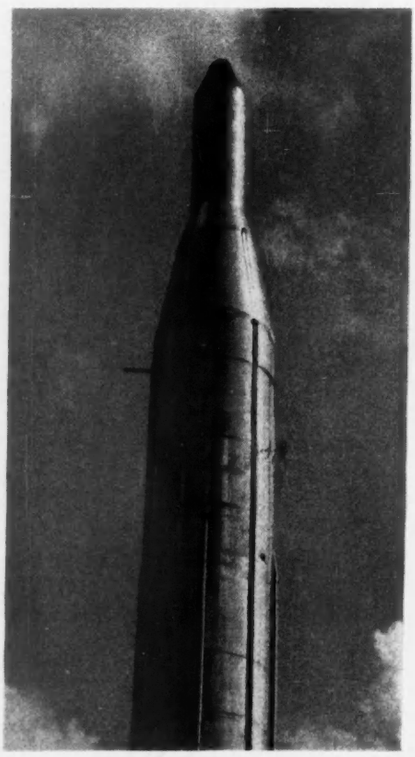
THIS year's exhibition includes very few new aircraft, and in consequence particular attention has been given to organising a flying display that should command attention irrespective of the interest elicited by the various machines taking part. Consequently the demonstrations by the Royal Navy and the Royal Air Force are more ambitious and elaborate than before. Flying commenced with the take-off of a Vickers-Supermarine "Scimitar" on a photo-reconnaissance mission, after which sixteen black Hawker "Hunter" aircraft of No. 111 Squadron, Royal Air Force, taxied on to the runway. The take-off was not in mass, since many of the machines would have been aspiring hot exhaust gases, but in groups of five, four, five and two. The photo-reconnaissance "Scimitar" then came past in a low-level pass to take photographs of the spectators: ostensibly to reduce noise, it flew on one engine only in this pass. The "Scimitar" then came in to land, arrester hook trailing: it was forced hard down on to the runway to demonstrate the very great energy dissipation furnished by the undercarriage.

The next aircraft demonstrated was a de Havilland "Comet" 4B. When this aircraft first appeared at Farnborough, ten years ago—it will be recalled that it was only the second jet airliner to appear at the S.B.A.C. exhibitions—it had a gross weight of 105,000 lb and "Ghost" engines of 5000 lb thrust: in contrast the 4B has a maximum loaded weight of 158,000 lb and the 4 and 4C have just been increased to 162,000 lb, all with 10,500 lb "Avon" engines. This example, finished in the new B.E.A. colours with the red wings conspicuous, was quiet but slightly smoky, and markedly smoky as the engines were throttled back. Reverse thrust was used at landing, but the touchdown was some way past the spectators, and it was not possible to assess the acceleration evoked.

The Royal Air Force demonstration now took place, 111 Squadron performing in two formations of nine and seven. Whereas in previous years the manœuvres have been dictated by the need to keep a group of aircraft in sight of the spectators, this year the two formations took turns to hold attention, and the evolutions consisted mainly of slow, deliberate, elegant rolls and loops.

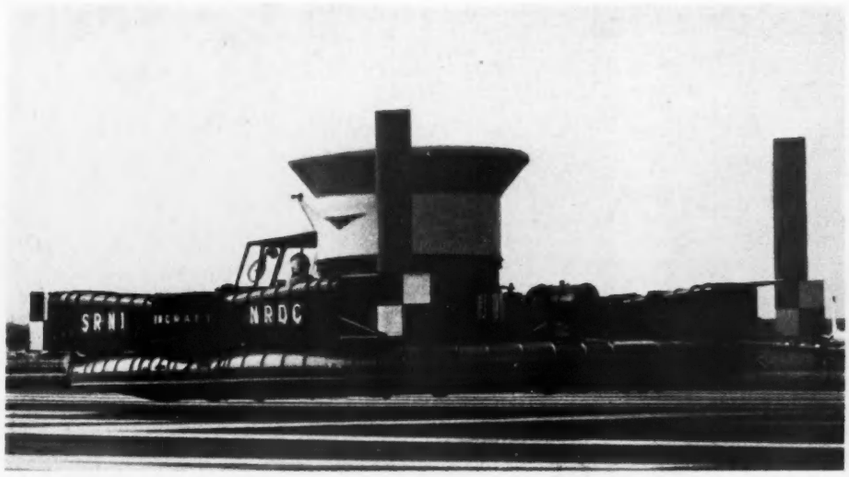
The Royal Air Force also flew past flights of "Victor" and "Vulcan" bombers and of "Javelin" interceptors, and a "snake" of Transport Command aircraft: the incredibly extensive operational commitments of this command are evident when its equipment ranges from the Bristol "Sycamore" to the "Britannia." Two "Jet Provost" trainers then performed aerobatics: most of the evolutions were performed with the aircraft not in formation but flying on "mirror images" of each other's tracks, and smoke trailing from canisters on each wing allowed the accuracy with which this was done to be observed. The "Hunter" squadron now returned as a formation of sixteen, and in the course of a large loop four aircraft broke off from each side. The remaining eight went into a second loop and on the downward leg executed a "bomb burst" emphasising their courses with smoke trails: the second eight then pulled up into the smoke, smoking themselves, and performed a "burst" in the opposite direction. The sixteen then landed individually: although the machines were obviously fast and sensitive in the approach, all except one touched if not settled down on the runway before reaching the white-painted threshold—and they landed in less than 160 seconds.

The Scottish Aviation "Twin Pioneer" was altered in appearance by the incorporation of equipment for geophysical prospecting. Electromagnetic apparatus developed by the Mullard research laboratories is carried in order to detect masses of conducting material, such as metallic sulphides, in the earth. The transmitting and receiving elements need to be widely separated, so that the wings have been extended, resin bonded glass fibre being used for both structure and fairings to avoid spurious electromagnetic influences: for the same reason the ailerons are fabric-covered and have glass-fibre trailing edges. The starboard wing carries a transmitting coil and the port wing a receiving coil, and a secondary winding on the transmitter is adjusted to exactly annul the received signal when the



The Saunders-Roe "Black Knight" is seen here with its solid-propellant second stage in place: the contrast between the sizes of the stages reflects the low performance of the first stage oxidant, H.T.P.

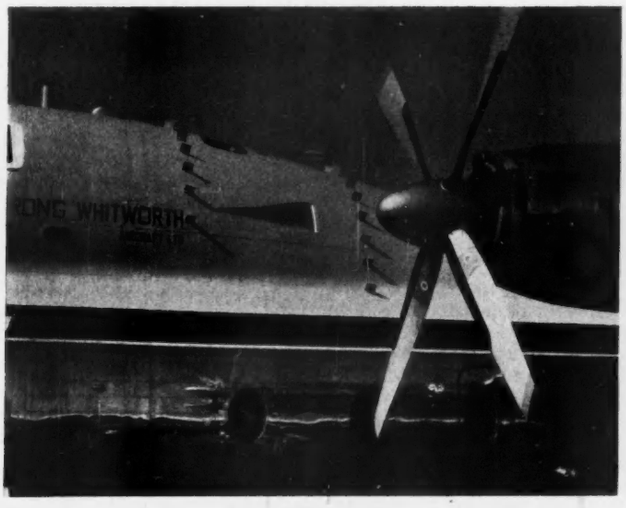
The Armstrong Whitworth "Argosy" freighter-coach transport in flight. The pressurised hull has both nose and tail ends hinged for rapid loading and unloading

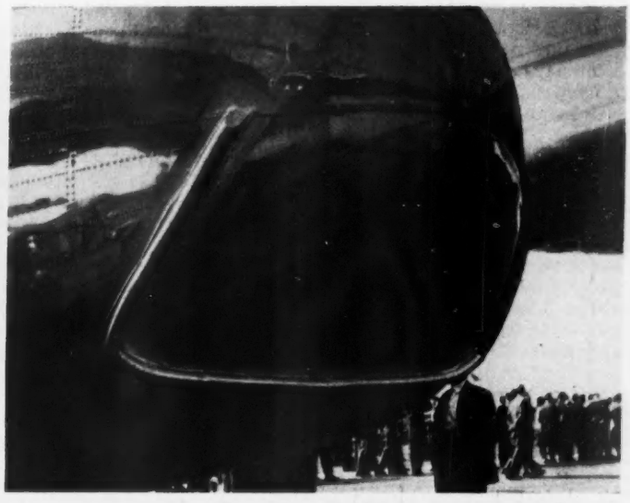


The Saunders-Roe "Hovercraft" floats on a cushion of pressurised air contained by two "curtains" in the form of inwardly inclined jet sheets

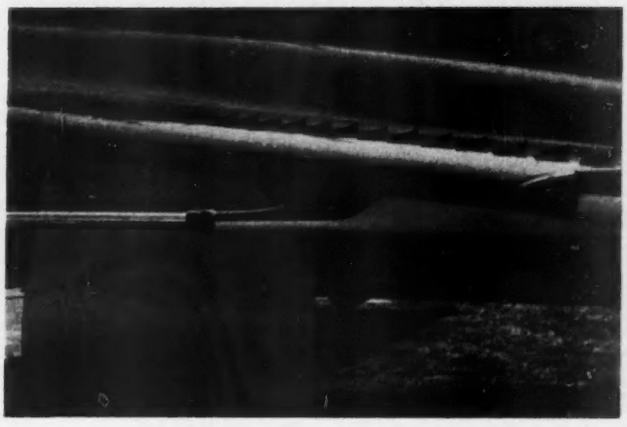
aircraft is flying out of range of any ground effects: the coils are set with their axes vertical when the ore bodies are likely to extend horizontally and vice versa. An eight-channel Edin recorder accepts the signals from this equipment on two channels, both in-phase and quadrature components being necessary to distinguish between valuable deposits and poor conductors such as swamp, a nearby frequency to indicate the amount of atmospheric noise, and the signal of a strain gauge on the wing having to monitor any gusts which might lead to false results. Three of the remaining four channels are devoted to a magnetometer, a Nuclear Enterprises scintillometer, and a G.E.C. radio altimeter. There is also carried an "Aeropath" camera recording the track, not on separate frames, but on a continuous strip of 35mm film. The flight demonstration comprised the expected short take-off and then a slow approach almost at right angles to the runway with a tight, steeply-banked turn on to the runway at an altitude of only tens of feet.

Two more aircraft in the new B.E.A. colours were now waiting to take off, the H.P. "Herald" and the Vickers "Vanguard," and the noise of, particularly, the two "Dart" single-shaft engines idling almost completely drowned the sound of the Saunders-Roe "Hovercraft." Rising from the grass in a cloud of dust, the "Hovercraft" floated up and down the runway, trimmed slightly nose-down, presumably to make more acceleration available. This machine is a classical example of a device in which inertia forces are large compared to both thrusts and drags: on the other hand, its polar moment is low and the yaw control is quite powerful, so that when it is desired to turn round and follow a reciprocal, rotation is completed while the machine is still floating in the original direction. The very stable load-altitude relationship was demonstrated by embarking twenty fully equipped Royal Marines, estimated to weigh 2 tons, most of

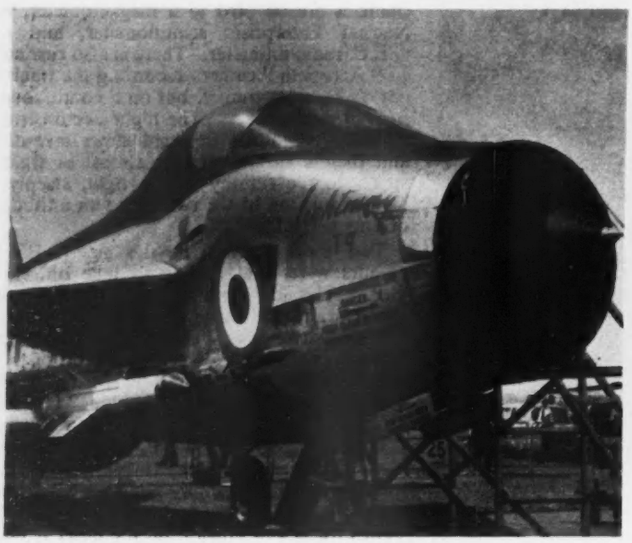


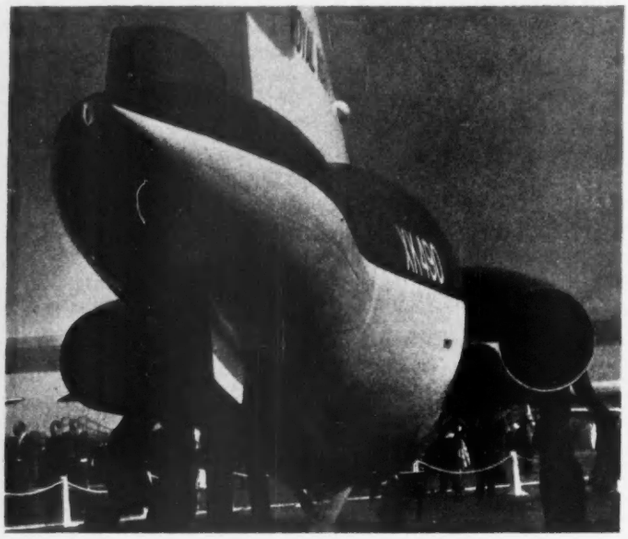


The distinctive shape of the "Argosy" hull results in aerodynamic problems. (Left) Vortex generators behind the flight deck. (Right) Location of separation on the near door



Boundary layer control is an essential contribution to the Blackburn N.A.-39. The wing carries vortex generators, needed probably at high Mach numbers, so that the laminar flow established by blowing from the slot cannot be sustained and must merely avoid a separation bubble above the front of the wing





(Left) The "Lightning" T.4; notice the bulge needed to pass air back to the upper engine. "Firestreak" missiles and an auxiliary tank are carried
(Right) The air brakes of the N.A.39 are very large in order to offset the reduction in drag caused by running the engines to obtain boundary layer control

them on the rear deck: the craft then flew very few inches high.

An Auster "Aiglet Trainer" was put through a series of unorthodox aerobatics, featuring stall turns and rolls carried out in the climbing leg of a loop: at landing it was touched down on one wheel for many yards.

The "Herald," which has not previously performed at Farnborough in twin-engine form, gave a short demonstration, including a fly past with one engine feathered that ended with a climbing turn against the dead engine.

The Fairey "Rotodyne" then lit up its tip jets and lifted off, the steam-engine-like noise of the rotor audible above the howl of four Rolls-Royce "Tyne" turbines idling. At the end of its flight it settled vertically down on the grass and debouched a large party of nurses.

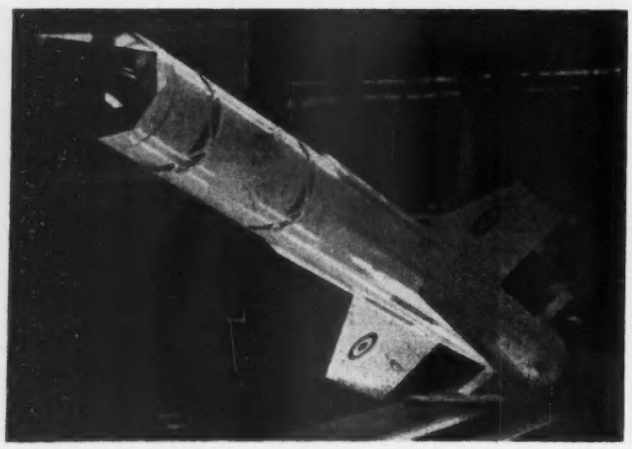
The "Vanguard" then took off, with a noticeably short ground run, flew quietly past, and returned: it touched down at the extreme rear end of the runway and was arrested with reverse thrust in a very short distance.

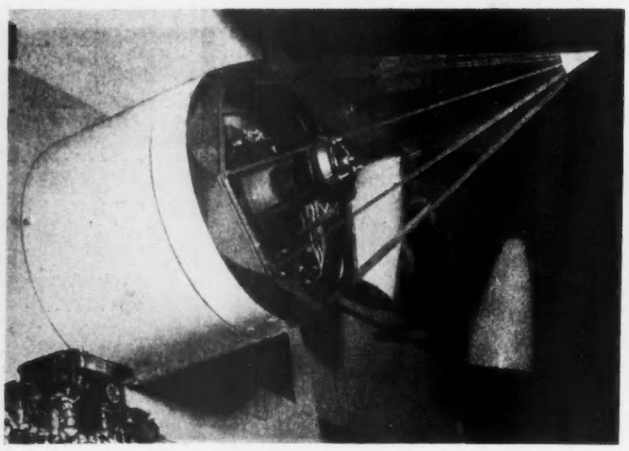
Another four-turboprop aircraft new to the flying display was the A.W.A. "Argosy." The unusual shape of this machine has given rise to some interesting detail design, as seen in our illustrations: behind the flight deck numerous vortex generators are provided to avoid separation, while on the bulbous rear door a "turbulator" of extraordinary depth is fitted to locate separation. One feature of its performance that could not escape notice was that when the four "Dart" turbines were idling they were running in and out of synchronism with a most penetrating resonance. In flight, also, the thrash of the propellers seemed obtrusive.

This was the first occasion on which the Blackburn N.A.39 has been available for inspection on the ground at Farnborough. Our illustrations show detail differences from the original appearance, the serrated strakes on the air brakes having disappeared. We also illustrate the provision for boundary layer control by blowing: a narrow slit, its rear edge rounding smoothly into the wing upper surface, runs the whole length of the outer wing (the aircraft was not seen to fold its wings) and another narrow slit faces rearward above the gap between the wing and the movable trailing surfaces. One notable feature of the aircraft is the rugged design of the exposed ram and lever for the large aileron. At take-off the short-span flaps were fully down and the ailerons drooped, and the same configuration was used at landing. In between, the machine performed hesitation rolls, first slowly and then fast: in the approach it did not seem particularly slow, but it was steady and apparently well under control.

The Avro "Vulcan" II took off in the opposite direction to normal, so that it had the gradient and a small component of a faint cross-wind against it. Despite this, it was climbing steeply with wheels retracted by the time it passed the spectators, and the volume of noise suggested a reason why it had chosen to run up its engines far down the runway. Three of the four Bristol "Olympus" engines smoked heavily when giving high power. The demonstration included not only the usual slow and fast fly-pasts, but also an acceleration from low speed into a steep climb. It should perhaps be recorded that the "Blue Steel" with which this bomber is to be armed was this year in evidence neither on the ground nor in the air.

An unusual feature was added to the display by the performance of a Hawker "Hunter" two-seater in its latest form, the Mk. 66A, which can function as an interceptor or ground attack fighter. A two-seat "Hunter" is used by the Empire Test Pilots' School to demonstrate the spinning characteristics of modern aircraft, and the Mk. 66 was climbed nearly vertically for several thousand feet and then allowed to descend in a spin, white smoke trailed from the





The D.H. "Firestreak" infra-red homer has a gimballed heat-seeker in its transparent nose and a separate set of detectors behind two rows of windows to feed information to the fusing system

tail-pipe rendering visible the eleven turns completed.

Another two-seat version of a single-seat fighter flown was the Folland "Gnat Trainer." While the trainer shares many components of the original machine, it has a larger wing of thinner section, and the conventional arrangement of flaps and ailerons instead of roll control by differential deflection of the flaps: this latter change is probably less because wing torsional stiffness is not a problem than in order that the trainer shall resemble operational aircraft. The second pilot sits under an extended canopy, and the fuel tankage lost is made up by tanks outboard of the air intake ducts, where the Aden guns of the fighter were. The two-seater, flying in company with the fighter, demonstrated the manœuvrability associated with this design, and finished the flight by opening its braking parachute while still flying quite fast a foot or two clear of the runway.

Yet another two-seat modification of a fighter made its first appearance in the shape of an English Electric P.11 inscribed "Lightning T.4." When running up before take-off this machine was venting smoke from the dorsal fin, presumably from the upper engine bay: it and the F.1 aircraft lit their after-burners during the take-off run, as is not usual. The full performance of the machines was not, of course, demonstrated, but it was noticeable how very rapidly a steep turn could be attained and abandoned. The "Avon" engines smoked markedly on reheat and also, it appeared, under excess *g*.

There then took place the customary mass demonstration of Westland helicopters. One of the two "Westminster" "flying crane" machines, having more extensive fairings in front of the engines and behind the rotor pylon, flew only for a few seconds: the other picked up a long aluminium bridge girder of unspecified weight and flew with it to a prepared pair of emplacements. The very great yawing inertia of the girder proved too much for the small fins at one end of the girder, and it actually arrived, yawing fast, "tail" first. Sappers caught traces dangling from its ends and guided it into place: the "Westminster" hovered very low over it and then flew away. A "Wessex" then air-lifted a Royal Marine "Land-Rover" and a "Whirlwind" a "Harrier," both of which drove over the bridge. A civil "Widgeon" was flown with flotation bags inflated. These Sikorsky derivatives were accompanied by two smaller helicopters, a "Skeeter" and a P.531 powered by a Blackburn A.129 engine, making the first occasion this engine has appeared in the display.

The flying culminated with a display by No. 807 Squadron, Royal Navy, using "Scimitar" strike fighters. One machine carried a full load of tanks and a bomb externally, while another had its arrester hook provided with an extension for "snatching" towed targets (this one, like the previous twin-"Avon" aircraft to fly, vented grey smoke from the engine bay before taking off), while the remaining four were "clean." The "snatch" is done by erecting two 12ft poles 20ft apart with a loop on the nylon tow line stretched between them: to help the pilot see these poles, a further pair 25ft long with flags at their tops flank the first ones, 150ft apart. The target, a "dart" of plywood and angle iron, rests at the end of the line 2000ft away in the direction of flight. Thus by the time the line is tight the aircraft has gained a great deal of height and the target is lifted off rather than dragged along the ground. The dart carries a smoke generator to make it visible and, presumably, to attract heat-seeking missiles.

The "Scimitar" with external stores demonstrated a L.A.B.S. (Low Altitude Bombing System) attack. Approaching the target low and fast, it pulled up quite gently into a deep loop and roll off the top: the Naval commentator counted a ten-second interval between release of the bomb and the appearance of a fireball, from a simulated tactical atomic weapon, half a mile or more away.

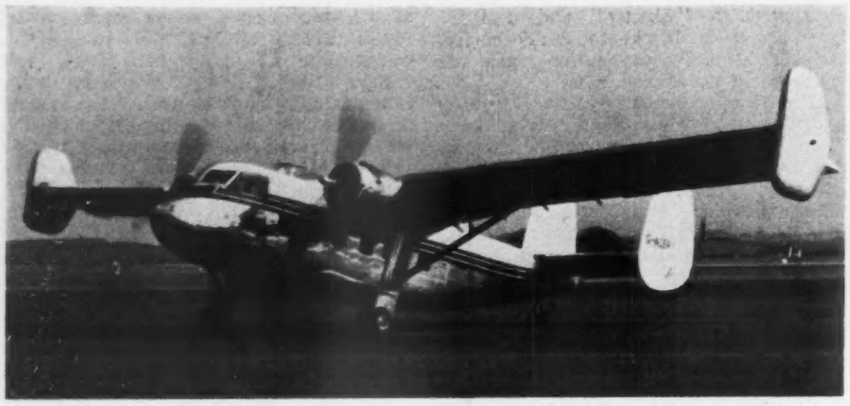
The four aircraft flying in formation performed what was announced as a "twinkle roll," each machine doing a flick roll in the same direction.

The landings of the heavy attack aircraft were a striking part of the demonstration. First, two machines landed side by side, folding their wings during the ground run to make room for the third, which touched down directly between them going in the opposite direction: the two then stood with their wings folded in the undershoot area and the remainder passed close above them as they approached in formation. As can be imagined, in all cases the "Scimitar" appeared very steady and controllable at low speed. Some guidance as to the performance of the "Scimitar" was given: target towing has been performed at above Mach 1, suggesting that the application of area rule has delayed the drag rise to supersonic speed and there is ample thrust to spare at M.1 which, clearly, means that this is the fastest British aircraft ever to become operational. It was also stated that, even without flight refuelling, provision for which is standard, its range is greater than that of any other Royal Navy aircraft, which is a remarkable claim for a jet aircraft.

Missiles

An important exhibit was the quadruple launcher for the Short "Seacat" missile, intended for use in close-range anti-aircraft defence and as ship's secondary armament. The vehicle itself is derived from the SX-A5 shown last year, having a cruciform of moving wings and fixed tail surfaces: the wings are quite heavily swept, probably to save stowage space, since the tail section does not suggest a speed of more than Mach 1, so that instant readiness would indeed appear essential if an attacking aircraft is to be destroyed before it has discharged its stores. The most interesting feature of the weapon is the guidance employed. Films of the SX-A5 showed it to carry flares, suggesting that visual tracking was used to close the loop and that command guidance was employed: obviously, command guidance with a human operator could not be employed against a difficult target, and this cannot be true of "Seacat." Consideration of the characteristics of known systems strongly suggests that "Seacat" is a beam-rider, and that the known shortcomings of this guidance—inaccuracy at long range and systematic error with curved flight paths—are mitigated by the beam being, not locked on the target, but laid by a crew member observing the course of the missile. Thus if the missile was seen to be likely to pass behind a moving target it could be brought on by aiming off with the beam. The equipment for producing and directing the beam was not displayed, and it cannot be recorded here whether it includes a stabilised platform or whether the layer has to cancel out ship's motion. Since the beam does not spring from the launcher, the problem of getting the missile into the beam and preventing it getting on a side lobe must arise: presumably an initial heading command will be fed in automatically depending on the directions in which launcher and transmitter are facing. The flares on the missile will enable the layer to see when a missile is in flight; fusing is presumably by a proximity detector. An attractive feature of such a system would be that it would introduce no techniques new to the Royal Navy, beam riding affording guidance also to the "Seaslug."

(Left) Models of the Short "Seacat" on a ship's launcher. The disc below each missile is the end of the cylindrical container within which the missile is loaded on to the launcher. (Right) The "Malkara" wire-guided anti-tank weapon weighs 200 lb and is fired from the turret of a vehicle



"Twin Pioneer" with glass-fibre extensions and antennæ housings for geophysical prospecting

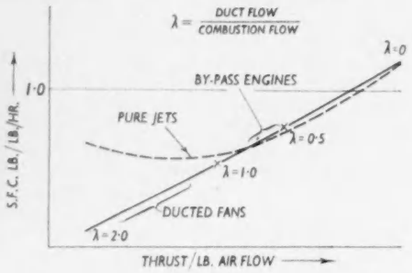
There was displayed a picture of the proposed "Tigercat" for use on land: it portrayed an armoured vehicle with four missiles on its turret, surrounding a very large part-spherical radome. The kind of guidance described above cannot, however, be postulated as acceptable for battlefield use, since fleeting targets will often be presented—troops cannot be concentrated for protection against aircraft—and because the loss of accuracy with range will, when engaging low-flying aircraft, be accentuated by the loss of fidelity due to the beam being aimed low along the ground.

The exhibition also included the D.H. "Firestreak," seen on page 214. Through the transparent windows, comprising the octagonal-section nose, can be seen the infra-red seeker: the detector itself faces away from the source, and radiation falls first on a reflector. Cell and mirror are mounted on gimbals, which occupy the greater part of the cross section, the remainder of the equipment being out of sight behind them. The acute problem of fusing a weapon with passive homing is tackled by the methods of optical rangefinding: there are two bands of windows at intervals along the nose, and some means which is not apparent is provided to scan the nearly cylindrical volume surrounding these windows. It can be visualised that only sources very near to the missile will be detected at one set of windows and not the other: since the weapon is only expected to perform pursuit interceptions with relatively low closing speeds, the time interval needed for a source to pass from the field of view of the front window to that of the back is not imperceptible.

Also on view was the Australian "Malkara" anti-tank weapon on order for the Army. As our illustration shows, it is a very large example of this class of weapon, and it is controlled by moving wings—thus it is in strong contrast to British practice, which favours fixed wings and moving tail planes, even for use against moving targets. The wings are wooden and the tail surfaces of remarkably flimsy hollow wood construction: the body changes from circular at the nose to square in way of the wings and back to circular around the solid motor without any subtlety. Weighing 200 lb, including a shaped charge of 50 lb or 60 lb, the "Malkara" is intended to be launched from the turret of a vehicle in the direction of the target, being guided through trailing wires by an operator watching it through a monocular viewer. The size is dictated by the desire to destroy the most heavily armoured vehicle with one shot and to have a range of about 2 miles.

Power Plant

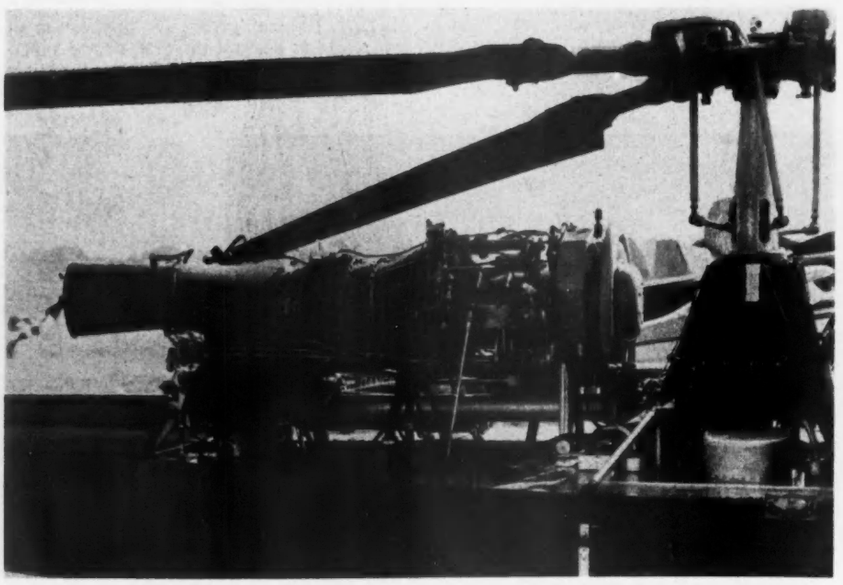
One interesting new engine appeared in the exhibition, the Bristol-Siddeley B.E.58. This, like the military B.E.53, is a ducted fan engine: the reason why such engines are attractive is apparent from the diagram reproduced here, and confirmed by the performance figures—14,500 lb thrust for a weight of 2600 lb, and a specific consumption of 0·572 hr.$^{-1}$ sea level static, rising to 0·8 cruising at the tropopause. These extraordinary figures immediately raise the query why such engines are so scarce, particularly since the designs inherited by Armstrong Siddeley from Metropolitan-Vickers included the aft-fan F.5. The answer would appear to be that civil operators were unable or unwilling to pay for the evolution of engines quite different from military units, and adequate performance for military purposes could be obtained from simple engines: further, military development tends strongly to be directed towards the extreme performance aircraft. It may perhaps be observed that once the importance attached to the high subsonic civil aircraft in the United States of America led to the development of ducted fan engines, they were adopted for installation in subsonic military aircraft. This, it may be remarked, illustrates one difference between by-pass and ducted fan engines, the by-pass engine being usable in supersonic flight: the fundamental distinction between the two is that in the by-pass engine the duct flow depends strictly on the density of the air at the compressor intake (at a given engine speed), while with a ducted fan the thrust is sensitive to intake velocity.



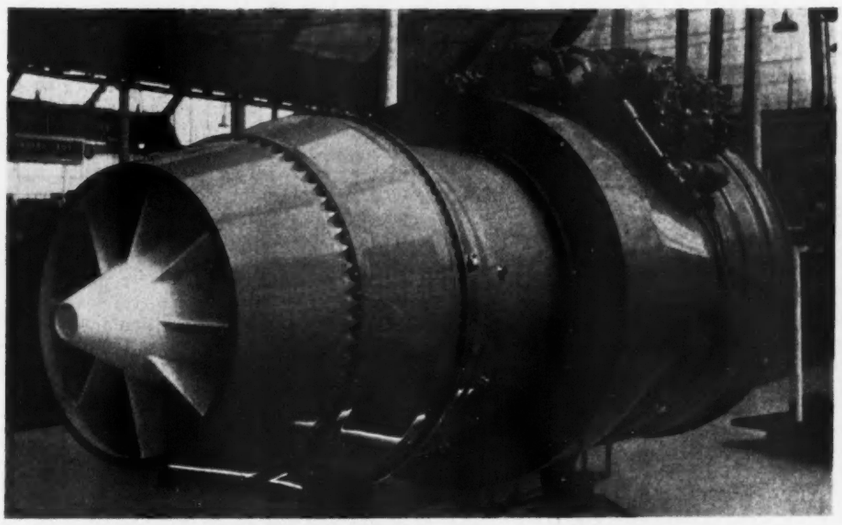
Performance of engines for a given maximum turbine temperature (full line) and given flight conditions

A ducted fan engine is being developed by Bristol Siddeley under the Mutual Weapons Development Programme.

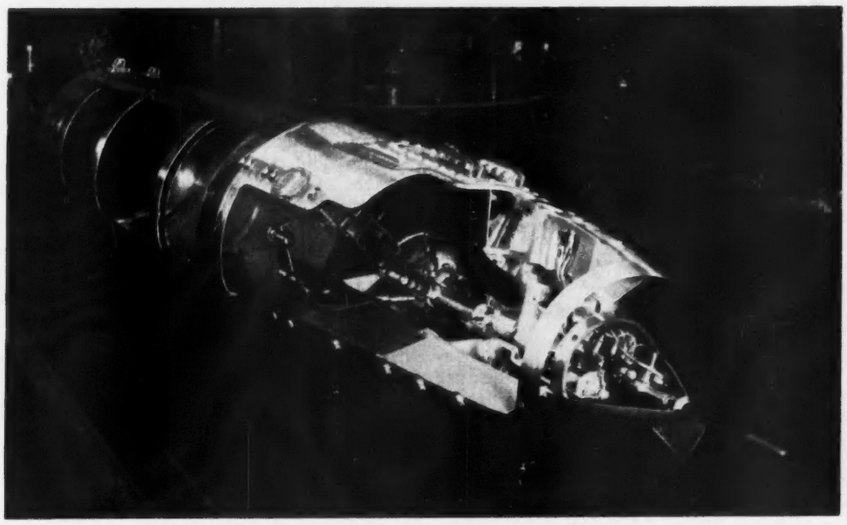
An exhibit which, while not new, was of particular interest technically, was the first cut-away ramjet ever exhibited at Farnborough. This was a Bristol "Thor" BT–1, as fitted to an early version of the "Bloodhound." This 16in diameter ramjet is claimed to give about 19,000 lb thrust at Mach 3. It is built principally from sheet steel, with a number of castings in the annular forward section. The centre body is supported on three vanes and the airflow is further subdivided by three intakes for the pilot combustion chamber behind the centre body. The close-up picture shows the nose cone, to which fuel is pumped through one of the vanes: the entire cone is full of fuel under pressure, serving as an energy source for the fuel control unit (which exhausts up the outermost annulus of the probe to the ring of holes far forward on the cone) and suppressing distortion due to large differences and rates of change of temperature. The pitot head provides a total pressure signal and one of the three tubes in front of the fuel tract, presumably, static pressure, while another of the three must carry thrust commands from the guidance equipment. Fuel metered by the air/fuel ratio control unit passes back through a non-return valve and



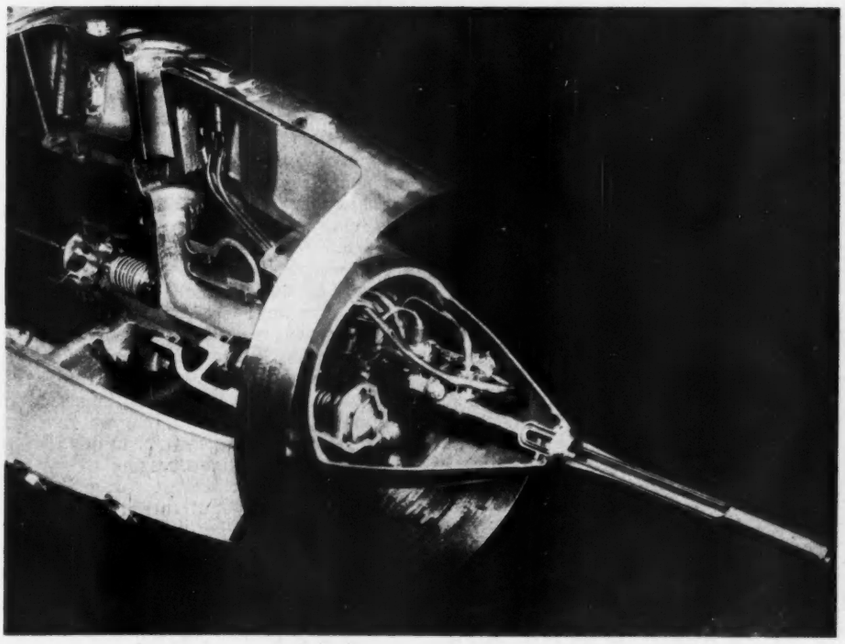
The Blackburn A.129, which has two transonic stages in its low-pressure compressor, seen in a P.531 helicopter



The Bristol Siddeley BE-58 is the only modern British ducted fan of which any details are available. It is claimed to have a specific fuel consumption of 0·572 per hour, sea level static



Sectioned example of a "Thor" ramjet



Fixed geometry supersonic intake with air/fuel ratio control within the nose cone

then into three diverging pipes, each feeding one set of four sprayers, while part of the fuel continues aft to the sprayer of the pilot chamber. Combustion is stabilised aerodynamically in the pilot chamber, there being a swirler which, to some extent, masks the unevenness of flow from the three intakes, while in the main chamber there is a circular gutter as a flameholder : three radial gutters behind the pilot intakes allow the pilot chamber to ignite the main chamber. The perforated annular surround of the combustion serves to damp out pressure pulsations that would otherwise reach the casing. The simple convergent-divergent nozzle is cooled by air from the external flow.

(To be continued)

Obituary

L. H. A. CARR

We regret to record the death of Mr. Laurence H. A. Carr, M.Sc.Tech., M.I.E.E., A.R.P.S., which occurred on August 27. When he retired in 1955, Mr. Carr had spent thirty-five years in the service of Metropolitan-Vickers Electrical Company, Ltd., latterly as consulting engineer (patents). Additionally, he served as the organiser of post-graduate studies, in association with the company's education department. Mr. Carr received his technical education at Manchester University, and after some industrial experience joined Metropolitan-Vickers in 1920 as engineer-in-charge of large induction motor design. In this field he became well known for his work in connection with the development of the synchronous induction motor. In 1938, Mr. Carr was appointed engineer on special problems, and became patents consultant in 1943.

Mr. Carr was a member of the Institution of Electrical Engineers and was chairman of the N.W. Centre in 1942–43. He served on the Institution's council from 1945–1948, received the Ayrton Premium in 1922 and Extra Premium in 1950. He was a member of the Court of Governors of Manchester University from 1949 to 1955, and was a past-president of the Manchester Astronomical Society and Manchester Amateur Photographic Society. Mr. Carr was also a member of many technical committees and was the author of a number of papers and articles on engineering subjects. His wide interests included astronomy and the technical aspects of history.

F. H. PARKER

We have learned with regret of the death, on August 30, of Mr. Frederick Herbert Parker, engineering manager of Fairey Aviation, Ltd. Mr. Parker, who was forty-five, was born in Bristol and joined the Bristol Aeroplane Company, Ltd., as an apprentice in 1928. On completing his apprenticeship he went into the drawing-office, later transferring to the production organisation. In 1941 he became chief planning and production engineer and in 1947 he was appointed to be deputy chief development engineer. In those appointments, Mr. Parker took a large part in the production of numerous Bristol aircraft, including the "Beaufighter," "Brigand" and "Freighter," and in the development of the "Britannia" and early Bristol helicopters. Mr. Parker left the Bristol Aeroplane Company, Ltd., in 1951 to join Fairey Aviation, Ltd., at Hayes, Middlesex, as assistant chief engineer. Six months later he was appointed engineering manager, in which position he was responsible for the engineering of many aircraft, including the "Gannet" prototypes, the "Gannet" AEW.Mk.3, "Delta 2" and the "Rotodyne."

The Critical Importance of Transport and Communications

By SIR EWART SMITH, F.R.S.

No. I

In this, his Presidential Address to Section G of the British Association for the Advancement of Science, presented on September 3 before the meeting of that Association in York, Sir Ewart pleads, in effect, for more energetic and forceful policies for the improvement of land transport in this country. He shows that, whereas we were leading the world 100 years ago, we have since then fallen behind several other countries. On the roads attention needs to be given to urban transport and on the railways, especially to freight transport in larger (and fewer) wagons than are at present contemplated. He concludes: "We must redress the balance by far more capital development, particularly of the road system, and by training a greater proportion of our best minds in the understanding and use of science for this as for other purposes."

Scope of the Subject

IN its widest sense, transport and communications covers two broad concepts: first, the physical movement of people and goods and, secondly, the conveyance of information. In theory, at least, this includes the transfer of knowledge and ideas, and thus the whole field of education.

Although one is a physical and the other a non-material process, there are in fact basic similarities between them. Both go to the very roots of civilised existence; both require a very advanced degree of organisation and of communal effort, if they are to be effective by modern standards; the demands on each are changing at high speed, and both are absorbing an ever-increasing proportion of the nation's resources; both tend to be trammelled by the past and by the conservative attitude that derives from long existence. In passing, it may be remarked that just as the standard rail gauge is the same as the track of Roman chariots, some of our educational methods still appear to take too little account of the changes in the balance of knowledge and culture that have taken place in the last 200 years.

We cannot now change the rail gauge, but we can and should press forward with the modernisation of our educational system. By this I mean that all intelligent adolescents should be given a balanced education at school, covering both science and the humanities, and avoiding intensive specialisation at that stage; that university education should be greatly and steadily extended, and that we should face the longer period of such training that is now necessary for the applied sciences at least. Every other advanced country has recognised this need, and almost without exception they train a far higher proportion of their brighter citizens in engineering science than do we in Great Britain. This is despite the fact that our proportional need is greater than theirs.

The Role of the Engineer

In the mid-nineteenth century we had the most extensive and efficient transport system in the world, by land and sea; it was an essential complement to our rise to pre-eminence in industrial manufacture of every kind. The creation of this system, like the rise of productive industry, was primarily due to the inventive genius of our engineers and the vigorous application of their ideas to practical ends. But they did more than invent, design and construct in the technical sense, for in large measure they also organised the business sides of the ventures they had conceived. Watt, Brunel, the Stephensons, Bessemer and Parsons, are cases in point.

When, to-day, we compare transport at home and abroad, we can hardly be satisfied that we have kept pace with the general advance of the last thirty years in regard to our road and rail systems. This relative change in our national position is another reason why transport, in spite of its economic and political, as well as its technical considerations, is appropriate for discussion by the Engineering Section of the British Association. I believe that our present position is in part due to the fact that in this country professional engineers have tended to become increasingly concerned with the purely technical aspects of their work, and to confine themselves to research, and to the design and construction of projects that non-technical managers and administrators ask them to undertake. Abroad, the engineer of appropriate type more often undertakes a much wider role, including a share in administration and general management.

We engineers are ourselves partly to blame for this converging trend to more specialisation, because of the sheer interest and satisfaction that so often stems from our work. In part, too, it is the result of the woefully small numbers of scientific engineers that have been trained in Great Britain relative to the need for the immediate technical jobs that have to be done. But whatever the cause, the inevitable result has been a tendency for engineers to play a relatively smaller part in affairs outside their specialist role. Given wide training, and by the very nature of his activities, the engineer should often be well placed to decide what ought to be done, as well as how it should be carried out in technical detail. To say that is not to argue that the technologist should be "on top" rather than "on tap" as the administrators might prefer; it does imply that there should be a better balance than now exists in which the well-trained engineer would often take a much larger share in general management. The advance of science and technology is steadily creating new sectors of specialised knowledge, but this only enhances the need for a proper supply of scientists and engineers with wide understanding who can link these specialist activities together in an effective way.

In support of this thesis, I would cite the rapid progress of development in atomic energy, in aircraft, in electronics, and the electrical industry generally: in all of these the scientific engineer has not only designed, but largely organised and managed. Where mistakes of policy have been made in these fields, they can often be traced to requirements, or decisions, determined by people with little or no technological background. In the heyday of railway development in this country, and more recently in France, where such great strides have been made in the post-war years, the engineers were largely involved in policy decisions and in general direction, in addition to their technical responsibilities. Because in some fields of transport engineers have become largely confined to purely technical work, I believe there has been a real loss to the community of the sort of vision and courage that the pioneer engineers displayed and that those in some of the newer industries show at the present time.

The Importance of Transport and Communications

So far as I am aware, there is no satisfactory official estimate of the proportion of the national effort that goes directly or indirectly into home-based transport and communications by land, sea, and air. An examination of the information available indicates for 1957 a gross figure of the order of £4750 million; it may well have been over £5000 million, if all costs could be ascertained. This total is made up of the operational and capital costs for roads and road vehicles (including road accidents), for the railways under the British Transport Commission, for civil aircraft and aerodromes, for British shipping, docks and harbours, and for Post Office expenditure where not otherwise included. These figures take no account of loading and unloading or administrative costs internal to factories; nor do they make any allowance for the value of the time spent by passengers in public and private vehicles, a very large figure indeed.

In 1957 the gross national product was approximately £19,000 million, so transport appears to account for not less than 25 per cent of the whole national effort. In material terms, therefore, there can be no doubt about the huge total effect of transport on the economy.

The basic facilities for transport in the form of roads, permanent way, stations, docks and aerodromes, as the case may be, demand space and capital works of civil engineering on the largest scale. By the very nature of these fixed installations, they can only be created slowly and, once developed, alteration is of the utmost difficulty. The need for vision in technical planning and for continuous capital development to keep pace with requirements increases with the complexity and acceleration of technological change. Here is an acid test of the community, a test of morale, of vitality and leadership; is there willingness to forgo some present consumption to provide the essential capital needs of the future? Can we, as a nation, feel very happy that we have done very well in this respect, and have our priorities been well chosen? Have we as engineers raised our voices as strongly as we should, or have we been so immersed in our own particular work that we have let these matters go by default? In this respect it was particularly encouraging to see the bold £142 million scheme for a London ring road recently put forward jointly by the engineers of the twenty-eight Metropolitan boroughs.

The mention of priorities inevitably raises wide issues of organisation, including national and local administration and the allocation of finance annually between competing departments. No one would suggest

* Address delivered to Section G (Engineering) on Thursday, September 3, 1959, at the York Meeting of the British Association.

weakening Parliamentary control of finance and taxation, but the traditional system of rigid yearly grants works against technical efficiency and inflates total costs for major projects. It is good to note the increasing trend to declare long-term rates of expenditure, as for the roads, or to the approval of schemes as a whole, as in the Railway Modernisation Plan.

But it is in connection with the priorities of capital works that the gravest doubts occur. For example, within the bounds of our present review, we find capital allocations to the Post Office of approximately £100 million per annum, whereas the roads have yet to rise to the promised £60,000,000 per annum. May one hazard an explanation of the smaller sum for the roads as being due to the Treasury's view that the Post Office can show a very proper and measurable return on its capital, but that roads are regarded as an unproductive overhead expense ? If there is any truth in this thought, it points once more to the need for a much greater influx into the Civil Service of people with technological understanding, and a better appreciation that ample and efficient overhead facilities, whether of competent, well-trained staff or in the form of material facilities, are a necessary foundation for efficiency in the modern world.

The Roads

Since 1946 the number of licensed vehicles has increased at an average rate of 8·2 per cent per annum, with no sign of change. From 1920 the rate has been of that order and has never fallen below 5 per cent per annum except for the 1930 depression and the war years. On existing trends, the present 7,000,000 vehicles will double in less than ten years. Should this happen, we should even then have only one vehicle per 3·6 inhabitants, against the U.S.A.'s figure of one per 2·6, and there the ratio is still rising at 5 per cent per annum. Traffic, i.e. vehicle miles, is growing generally at over 7 per cent per annum, and against this the expenditure on new roads and major improvements was £5,000,000 in 1948–49, £8,000,000 in 1954–55 ; and is to be £60,000,000 in 1959–60. But when regard is had to the fall in the value of money, even the £60,000,000 is no more than the pre-war rate of expenditure (£17,000,000 in 1938-39), and our effective rate of maintenance is rather lower than pre-war. In 1939 there were 3,100,000 licensed vehicles, and already by 1957 7,400,000—need more be said ?

There is the double problem of urban congestion and inefficient inter-urban linkage. At present most of our efforts are directed to the latter, but it will be of little benefit to speed traffic between towns, if it is to be bogged down at either end. Since Kingsway was built fifty years ago, central London has had no new main thoroughfare till the first part of Route 11 was opened this year ; the first modern flyover in London is still not complete. In comparison, Brussels, under the spur of last year's Exhibition, went far in two years to relieve her traffic problems by building several miles of new road and a number of under- or over-passes. It is reckoned that much of this work will be repaid by savings within five years. Of course, the financial and sentimental difficulties of urban improvements are very great, but we must decide whether we wish to become a museum piece, or keep our place in the modern world. Where, for reasons of history or architecture, there are streets or areas in our ancient cities and towns that we wish to preserve unchanged, these should be determined and the traffic flow strictly regulated or banned to give quiet pedestrian precincts. Similarly, we must be ready to provide for vehicular and pedestrian traffic at different levels. If ring roads and radial feeders are to be effective, they will often have to be completely new highways. Too often we select streets that connect up somehow and, by calling them a "ring road," imagine that our problem is solved.

After the Great Fire, London missed its opportunities in spite of Wren's vision. After 1939–45, we had Sir Patrick Abercrombie's Greater London Plan, but we had, too, a multitude of Authorities, Departments and Committees, who gave lip-service to planning. In the result we have done little of a major nature to retrieve the lethargy of the past fifty years. Indeed, far from providing freer movement, we have allowed the meanderings of our street system to silt with standing vehicles, till at times the flow is all but blocked. It is clear that highway parking must be stopped or drastically curtailed ; the community provides roads for movement and not for standage or storage to the general detriment. The multi-storey garage with modern handling aids can accommodate ten cars on the area taken up by one in the street. As to cost, the answer must surely be that those who make the demand must pay for the facilities.

When we come to trunk routes, we have had some appreciable improvement of existing roads, the 11 miles Preston by-pass, and the yet to be completed 50 miles of the first real motorway from London to Birmingham. But in comparison with the railway builders of a hundred years ago, and in relation to the present material wealth of the community, what puny efforts these are ! From 1830 to 1850 the average length of new rail routes built in Great Britain was 320 miles a year —built, let us remember, without excavators and bulldozers, without steel and largely without concrete ; built just with pick and shovel, barrow and cart. It is true that those responsible had a sense of urgency and a freedom of action that we now deny ourselves, but how the ghosts of Telford, the Stephensons and Brunel must weep to see our loss of vision, of courage and of vigour. But these great engineers were not just specialists working to instructions ; they were at the same time planners, designers, builders and managers. Not least, they were able to take responsibility and to develop the broad view from their early years.

To-day, there is no less genius available but, under the complexities of modern life and in deference to the idols of equality and collective responsibility, this genius is too seldom developed and given the opportunity to take individual responsibility. A few weeks ago I went through the new Amsterdam–North Sea Canal—it has the biggest locks in the world—and noted the road underpass provided ahead of future heavy requirements. I thought of all the talk of the Thames barrage, and recalled that we have not opened a Thames tunnel since 1908. Brunel built the first under the most appalling difficulties, and with what enthusiasm he would have built the barrage, as his counterparts could do to-day.

In the Road Research Laboratory, this country has a first-class organisation for research into road problems. Within its limited resources it is doing sterling work in technical development and in traffic analysis, including the causes of accidents and the methods by which they can be minimised. It is in no small measure due to its work that the gross accident rate to-day is little higher than it was pre-war, when there were half the number of vehicles and their power and maximum speed were far less. Nonetheless the total cost of accidents is now estimated at some £170 million per annum, to say nothing of the human suffering involved.

It is a striking and regrettable fact that we have no established centre for training high-grade traffic engineers, as is done on a large scale in North America and in some continental countries. The problems of traffic analysis, and its integration with highway planning and design, demand first-class minds with special training, and experience that cannot be got overnight. The supply of such people has to be deliberately organised and created, but as yet many of our authorities seem scarcely aware of the need for such help, or of the benefits they could bring. Because of our close-knit road system—agglomeration would be a better word—and the difficulties stemming from the long history of our towns, the need here is greater than in many other lands ; we are at last talking of university schools of traffic engineering, yet we have still to move.

The construction of the London–Birmingham highway promises to be a fine piece of work, carried out at praiseworthy speed. The lesson to be drawn is, surely, that it was planned as one entity, and the responsibility for design and execution was unified —to the credit of the Ministry of Transport. No doubt this was the easier, under the present organisation of highway responsibilities, because it was an entirely new scheme. If so, this is one more pointer to the need for a bold recasting of the present system, with its multiplicity of authorities and overlaps of responsibility.

Dr. W. H. Glanville, F.R.S., the present head of the Road Research Laboratory, and Dr. R. J. Smeed, in a noteworthy paper[1], last year summarised many of the factors and problems affecting the roads in Great Britain. They estimate that the average speed of motor vehicles in 1956 was 20 m.p.h. in urban districts and 32 m.p.h. in rural areas. The authors calculate, on a conservative basis, that a change in these speeds of only 1 m.p.h. would result in a saving (or loss) of £29,000,000 and £7,000,000 respectively per annum. If the value of non-working time is included at the same rate as in this calculation, these savings would be trebled to a total of more than £100 million per annum—and who would admit that his own leisure time was without value ? Under light traffic conditions on good roads, the average speed is 25 m.p.h. in built-up areas, and 40 m.p.h. in rural areas. Thus, if these speeds are taken as a not impossible bogy, the calculated savings on an economic basis would be over £200 million per annum under present conditions. Allowing for the value of leisure time, the figure would be over £500 million per annum.

The paper points out, further, that the time cost of delay increases at more than twice the rate of increase in the number of vehicles using the roads. Since the latter rate is in excess of 7·0 per cent per annum, the time cost of delay is rising at 14 per cent per annum, apart from any remedial measures that may be taken. While no one would wish to press such calculations too far, they do give a clear idea of the order of the loss (or saving) that the community has to consider when dealing with the road problem.

REFERENCE

[1] "The Basic Requirements for the Roads of Great Britain," W. H. Glanville and R. J. Smeed. *Proceedings of the Conference on the Highway Needs of Great Britain*, 1957. Institution of Civil Engineers. London, 1958.

(To be continued)

Century of Oil

By A. C. HARTLEY, C.B.E., M.I.C.E., M.I.Mech.E.*

No. II—(*Concluded from page* 185, *September* 4)

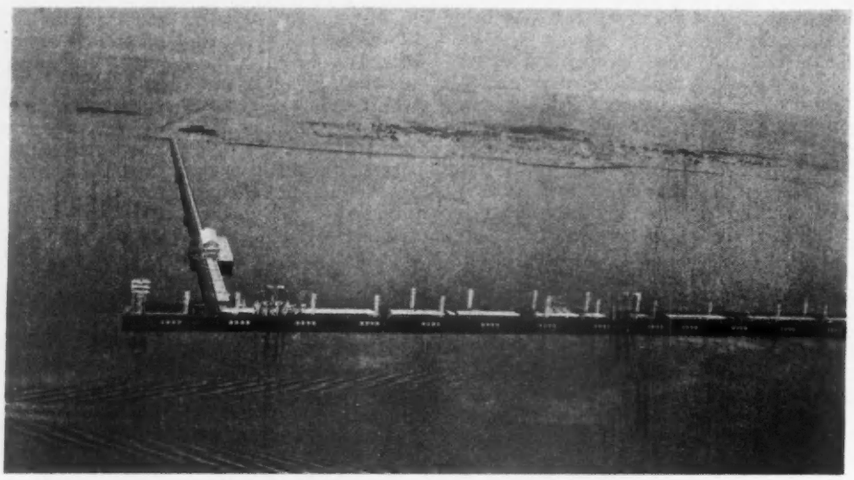
Developments Since 1956 and Probable Future Trends

THE foregoing has been based upon the author's article in the Centenary number of THE ENGINEER, published in 1956, and it is now interesting to note some of the developments in the international oil industry during the past three years; it will be seen that it is continuing to develop and at an increasing rate. The Suez incident gave a striking example of the flexibility of the industry and its ability to adapt itself to very sudden changes. The closure of the Suez Canal led to the re-routing of tankers and the switching of sources of supply. All this was achieved smoothly and markets were kept supplied.

The need for searching for oil in many new areas to establish more widespread reserves and for more flexible and economical means for transporting crude to the world's refineries was, however, very clearly demonstrated. The developments which have resulted will be briefly described under the headings used previously in this article, and probable future trends indicated.

Oil Exploration.—Improvements in all the instruments and facilities hitherto used for exploration have enabled a search to be made in previously inaccessible areas and in areas formerly thought to be uninteresting. One development has been in underwater exploration and all the progress made in diving and underwater equipment has been utilised to the full. More powerful echo sounder type of instruments such as the Sonoprobe and the Sparker, have been developed to explore below the sea bed in order to give geologists information regarding formation below the mud and also to give information of use when designing foundations. (This same class of instrument has recently been used in the Straits of Dover in connection with the Channel Tunnel scheme.) This has led to the discovery of further vast reserves of oil and gas in underwater areas, particularly in the Gulf of Mexico and more recently offshore from Persia, Kuwait, Saudi Arabia and other neighbouring countries. Great success has rewarded intensive efforts to discover oil in North Africa and extensive schemes are in hand and nearing completion for early production. Great use has been made of aircraft and particularly of helicopters for transport of materials and personnel.

Oil Well Drilling.—Steady improvements have been made in conventional drilling equipment, drill pipe, casing, valves, blowout preventers, &c. A good deal of progress is being made in the improvement of the efficiency of drilling bits by using the drilling mud at higher pressure and jetting through better designed nozzles in the bit to sweep away the cuttings before power is wasted in grinding them to powder. The life of the drilling bit has also been extended and even doubled by introducing high-pressure lubricants into the drilling mud. It has long been realised that means should be developed to apply the power directly to the bit rather than drive the bit through long strings of drill pipe. Considerable progress has recently been made in this direction by the development of turbine drills driven by high-pressure mud flush and also of electric motor-driven bits which, however, still require mud flush to remove the chippings. Although internal combustion-mechanically driven drilling rigs have been brought to a high standard of efficiency, much attention is being given to internal combustion-electrically driven rigs and to electrical hydraulic rigs and it is along these lines that important progress may be made. Attempts are also being made to introduce automatic hydraulic methods for manipulating drill pipe and running into and out of the hole with a view to making this time-absorbing operation as continuous as possible. Improvements may well be made in the drilling bits themselves by combining experiences in the coal and the oil industry and introducing diamond bits. The object of all these improvements is to avoid frequent changes of the bits and the time taken in pulling out and running into the hole. Wells have now been drilled to depths of more than 25,000ft, and means for drilling economically to much greater depths would be a welcome step forward.



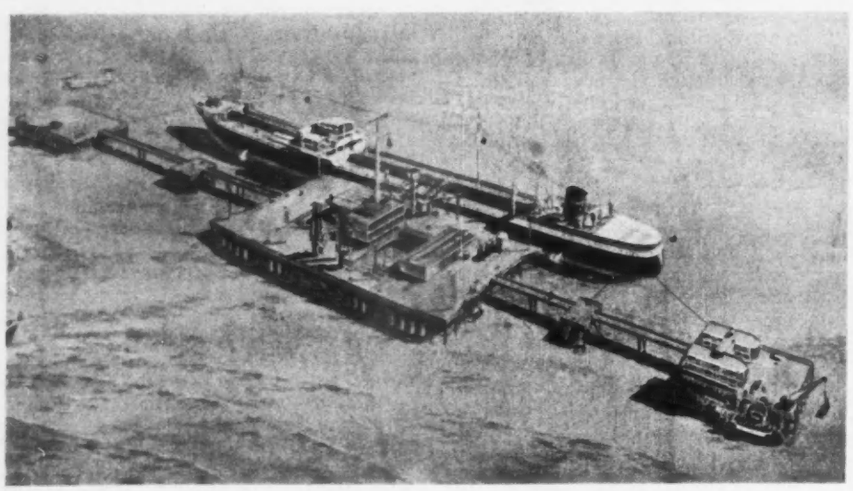
North pier, Mina al Ahmadi, of Kuwait Oil Company

Perhaps the greatest developments have been in plant and equipment for offshore drilling, enabling wells to be drilled in greater depths of water and extending the area of the Continental shelf from which oil can be produced. Recent developments in complete drilling platforms, some of which have been constructed in the United Kingdom and towed to the Middle East, have been fully described in the technical press. When on site they are raised to a height well clear of wave action by means of spud legs operated by automatically controlled jacks, and they can readily be moved from site to site.

Another simpler method is being successfully developed for deeper water in which the complete drilling platform remains floating and it has been found that ordinary drill pipe and casing have sufficient flexibility in long lengths to take care of the movement in its moorings. Many further improvements in offshore drilling methods and equipment may well be expected and their development offers great scope for engineering ingenuity.

Oil Production.—There have been few major developments during the last three years, but methods of secondary recovery by water injection and of repressuring of fields by the return of gas and products have been steadily improved.

Crude Oil Transportation.—Improvements in the quality of steel and in the method of producing welded pipe have enabled con-



Artist's drawing of new deep-water terminal at Fao, for Basrah Petroleum Company

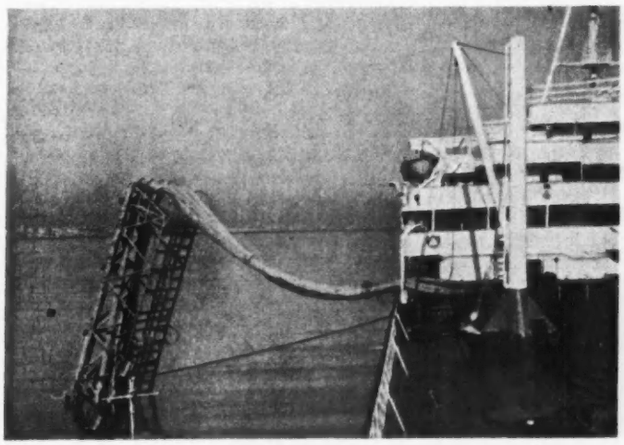
* Consultant to Rendel, Palmer, and Tritton; formerly chief engineer, Anglo-Iranian Oil Company, Ltd.

sideration to be given to using pipe of larger than the 36in diameter previously used to increase the efficiency of pipeline transportation. The production of spiral welded pipe is being rapidly developed and if plant for its manufacture can be made suitable for use on site, it will greatly reduce the heavy transport charges for large diameter pipe and be a major step forward. Automatic control of the pumping stations from a central control point is being used to a greater extent as a result of successful development in refined products pipelines. New methods of protecting the pipe against corrosion by the use of various plastic wrappings have been developed and successfully used and, together with improved cathodic protection, ensure longer life for a pipeline and increase the overall economy of pipeline transportation.

Refined Products Transportation.—During the past three years, great advances have been made in the fully automatic operation of products pipelines. The most recent example is the Gulf Oil Company's Laurel pipeline which has just been put into operation and in which provision is made to control remotely all operating units, to identify and to report batched changes and to study all off-take rates at terminals. Provision is made for the future addition of equipment for data reporting and computer analysis at a central control point. Many new lines have been commissioned or are now being built.

The ultimate in pipelines may well be a completely automatic system which can handle any combination of petroleum liquids with no personal supervision other than the service personnel to adjust and maintain the equipment which does the "thinking." One basic technique necessary to this idealised operation is a means of positive separation of products or crude so that not even minor mixing or down-grading takes place.

Oil Refining.—There have been steady developments in thermal reforming, catalytic cracking, polymerisation, alkylation and isomerisation, enabling the proportions and qualities of the various fractions to be adjusted to market requirements. The most important developments have been in connection with the petroleum chemical industry, which produces solvents, detergents, plastics and synthetic fibres, synthetic rubber, agricultural chemicals, glycerine and many other products—for example, anti-freeze compounds and a whole range of pharmaceutical products. The rate of increase in these activities is well illustrated by the expansion in the British Petroleum group's output, both in quantity and scope. In the United Kingdom the last quarter of 1958 showed a marked increase in demand, and sales of chemicals during that period were at the rate of 195,000 tons a year. Work has begun on a third cracker at Grangemouth and further plants for the production of polyethylene, phenol and acetone are due to begin operation this year.



Prototype hoister at Mina al Ahmadi raised from seabed with flexible hoses connected to tanker

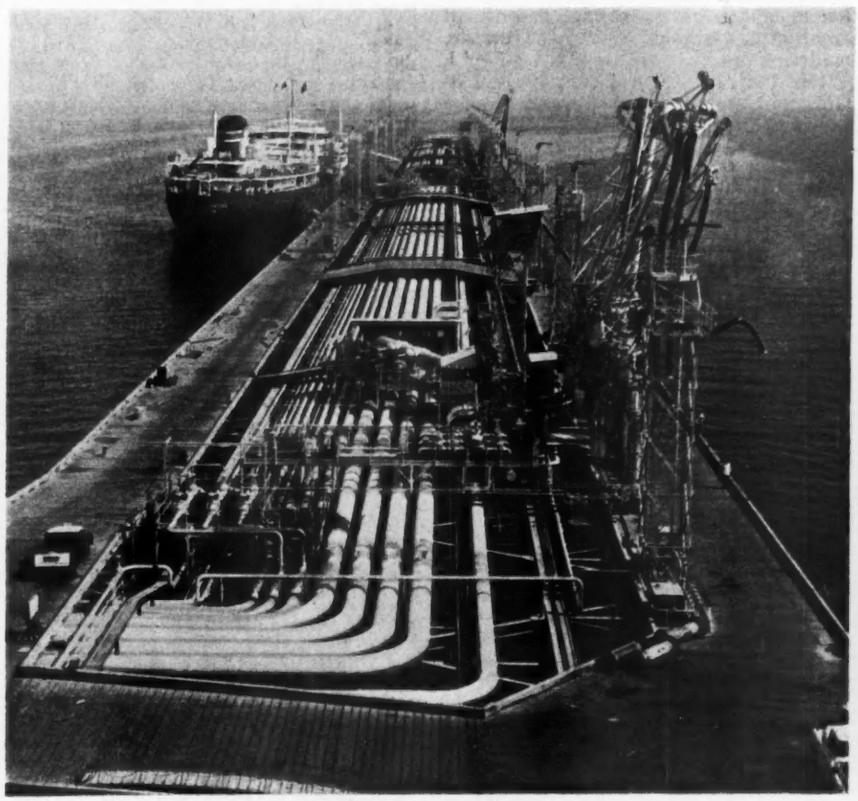
Oil Loading.—Major developments have taken place in the sea transport of oil during the past three years and have clearly shown that tankers are the more economical the larger they are, provided means can be made available for rapid loading and discharge at terminals. The world tanker fleet at the end of 1958 had risen to 55×10^6 tons deadweight, of which $4 \cdot 27 \times 10^6$ were between 35,000 and 45,000 tons deadweight, and 1·1, 0·1 and 0·6 between 45 and 55, 55 and 54, and over 65 respectively. Of the $25 \cdot 6 \times 10^6$ tons deadweight new building or on order, $3 \cdot 9 \times 10^6$ tons deadweight are over 65,000 tons deadweight. Tankers of more than 100,000 tons deadweight are in commission and more are building or on order.

It was estimated in a paper presented to the Fifth World Petroleum Congress that the transport costs in larger tankers, expressed as a percentage of those in a 16,000 tons deadweight, are 61 per cent in a 45,000 tons deadweight, 56 per cent in a 60,000 tons deadweight, 52 per cent in a 80,000 tons deadweight, and 50 per cent in a 90,000 tons deadweight.

The 32ft at low water which was adequate for the 16,000 tons deadweight, and 40ft for the 32,000 tons deadweight, have now to be increased to at least 55ft and depths of 65ft are being provided at many new terminals. Rates of loading and unloading have been increased from 3000 tons an hour to 6000 tons an hour to reduce turn-round time to a minimum. These facilities are provided either by laying steel submarine pipelines along the sea bed and using flexible rubber hoses to connect them to tankers moored at buoy berths or by constructing piers or docks sufficiently far out into the sea to give the required depth alongside which tankers can be moored.

Until recently, the loading or unloading rates at a buoy berth have been limited by the diameter of the submarine pipeline it has been possible to lay and the length of about 250ft of the hoses necessary to allow the tanker freedom to move in its moorings, and the diameter and number of hoses that can be used due to limitations of the weight of hose the tanker can lift out of the sea and the risk of damage to the hoses by entanglement if multiple hoses are used.

New methods of laying submarine pipelines have been developed during the past three years which have removed the limitation in diameter imposed by the old methods. One method is to use what is termed a "lay" barge, designed to provide facilities for lining up, welding, X-raying, completing the coating and lowering the pipe to the sea bed in a continuous operation. These barges are of considerable size and their movement along the line of the pipeline is controlled by anchors and guy lines from the corners of



The North pier, Mina al Ahmadi

the barge, forward movement being accomplished by the use of winches and the anchor lines. Very considerable care has to be exercised not to overstress the pipe when operating in deep water and also particularly in rough water. Another method, which has been successfully used by the Collins Construction Company on long, large diameter, submarine pipelines, is to weld the pipe continuously on the shore and pull it along the sea bed. It has been shown that if the weight of the pipe is correctly controlled, having regard to the specific gravity of the mud on the sea bottom, lengths of very many miles can be pulled by a winch on a barge, which is secured on the line of the pull at various stages by anchors or wire ropes previously laid and anchored a considerable distance beyond the end of the pipeline. Lines of 30in in diameter have been pulled in this way and schemes are in hand for considerably larger diameter pipes.

The limitations in throughput hitherto imposed by the use of long lengths of flexible hose at the end of submarine pipelines have recently been removed by the development of a device called a " Hoister," the prototype of which was successfully tried out by the Kuwait Oil Company at Mina-al-Ahmadi. The principle upon which the " Hoister " acts is to lift the connecting hose from the sea bed by means of buoyancy. To achieve this, the main part of the flexible hose is replaced by solid pipe to which is connected a container which, when emptied of water by air pressure, lifts one end of the pipe to deck level, the other end being anchored to the sea bed. In this position, the remaining parts of the hose act as a flexible connection between the sea line and the " Hoister " at the bottom and between the " Hoister " and the tanker at the top. The " Hoister " can be designed to handle the number and diameter of flexible hoses necessary to allow unrestricted flow through the sea lines, and may also be designed to handle simultaneously more than one product when more than one sea line is in use.

The prototype " Hoister " was designed to handle three 10in hoses for handling crude and one 8in to handle bunkers. The crude hoses were supplied through a 24in submarine line and the bunkers through a 12in line. The length of each line of hose was 20ft at the bottom of the " Hoister " and 60ft at the top of the " Hoister," or 80ft in all. The hoses previously used were 220ft in length and only two 10in diameter hoses could be used. The use of the " Hoister " enabled the full free flow of the loading system to be used and the maximum rate of loading was increased from 2640 tons an hour to 3530 tons an hour, an increase of 890 tons an hour, or by one-third. The next " Hoister " to be installed has been designed with a capacity of 6000 tons an hour for the purpose of unloading 87,500 tons deadweight tankers in 65ft of water.

The use of the " Hoister " is of particular advantage where soft sea bed conditions permit the standard arrangements of hose to sink into the mud, with the result that they are frequently damaged when efforts are made to raise them. It appears that the " Hoister " device can be designed to handle any number and diameter of flexible hoses which may be necessary to allow unrestricted flow through the sea lines and may also be designed to handle simultaneously more than one product when more than one sea line is in use. It will now be possible to install buoy mooring berths and submarine facilities for the loading and also for the off loading of the largest tankers where circumstances do not make the installation of the very much more expensive pier or dock facilities desirable.

During the past few years, many piers and dock facilities have been and are being constructed where very large quantities of oil are expected to be handled over a great number of years and where it is important to handle a large number of tankers on a narrow sea frontage. Many examples have been fully described in the technical press, such as the new terminal built by the British Petroleum Company at Finnart in Loch Long, with facilities for the unloading of crude from the largest tankers to supply Grangemouth refinery, and that now being built at Angle Bay, Milford Haven, to give the same facilities for the Llandarcy refinery.

During the past three years, the Kuwait Oil Company has designed and constructed their North Pier project, some 4½ miles north of their existing South Pier (see page 221). The new pier has an approach leg of 4750ft and has a minimum depth of water of 60ft at the pier head, which is capable of berthing two tankers 1000ft long on the seaward face and two smaller on the landward side of the pier head. Crude oil is delivered by gravity through 40in diameter lines with a head of 350ft. Gravity fenders which have proved so successful under similar conditions at the South Pier have been adopted for the North Pier, and it has twenty-nine groups of four gravity fenders, each fender weighing approximately 75 tons in air with a stroke of about 4ft. Each group of fenders, together with the pier structure, has a capacity of 670ft/tons and a 100,000 tons deadweight tanker will rest against four groups. Loading rates of 6000 tons an hour are being catered for. Expansion joints have been fitted at intervals along the 38in supply pipelines on the jetty approach.

A two-storey building has been built on portal frames over the pipe track to accommodate the Kuwait State Medical Quarantine Section and to provide tanker crews with recreational facilities. There are also administrative offices for the storage and export department, the ships' agents and the fire master.

The Iraq Petroleum Company is constructing a new deep water terminal 24 miles out in the Gulf from Fao, to increase the export capacity of the Basrah Petroleum Company. Five platforms, which will cost about £16,000,000, will be able to berth two tankers simultaneously, each of 64,000 tons deadweight capacity. The central platform will be about 400ft long and about 240ft wide. Two 32in diameter pipelines will be pulled along the sea bed to connect the terminal with the pump house at Fao and the loading rate, with both berths in use, will be 8000 tons an hour. When this terminal is commissioned, the export capacity from the Basrah fields will be raised from 12,000,000 to 22,000,000 tons a year.

Two De Long type of floating platforms will be used to facilitate the construction of the other platforms and will form a permanent part of the terminal.

Conclusion

The essential part that the international oil industry has come to play during the past century in the life of the world may be summarised as follows.

It provides petrol and diesel oil for the millions of cars, vans and other vehicles for the carriage of passengers and goods.

It provides fuel for every aeroplane, naval vessel and the vast majority of the merchant fleet.

It provides fuel for the increased food production achieved in recent years.

It provides oil fuel for the steel, pottery, glass and ceramic industries, and improves the quality and output of their products.

It helps the gas and electricity industries to increase their outputs.

It provides lubricating oil for 90 per cent of the world's requirements.

Oil is now helping industrial life by producing literally hundreds of petroleum derivatives used in processing and manufacturing products as diverse as insecticides, detergents, fibres, plastics, rubber, paint and artificial silks.

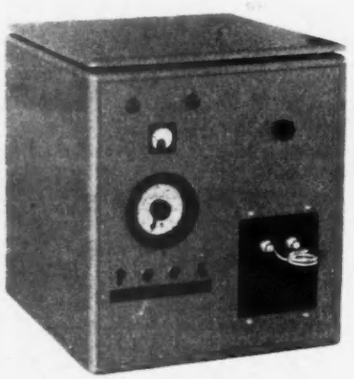
The industry is confident that adequate reserves of crude petroleum have been discovered and that further reserves will continue to be discovered to warrant an increased rate of expansion for many decades to come.

There are even vaster known reserves in oil shale and oil sands, which will undoubtedly be used when crude oil becomes less available and dearer, just as oil shale was brought into use by Dr. James Young more than 100 years ago when seepages and Cannell coal supplies gave out.

There are great opportunities for British engineers to help in the further expansion of the international oil industry, whether as direct employees in the oil companies or with consulting engineers or construction and manufacturing companies, and the magnitude of all these may be measured when it is realised that oil companies in the U.K. have placed orders amounting to £122 million in 1958. The total expenditure by the international oil industry during the last ten years is estimated to have been £25,000 million and the current estimate for expenditure during the next ten years is double this gigantic figure.

Process Heater Range Extension

The R.F. Heating Division of Pye, Ltd., 28, James Street, Cambridge, has begun the manufacture of process heaters for the metal trade after having manufactured radio-frequency generators for the wood trade during the last fifteen years. An induction heater which gives a continuous output of 3kW at 2 Mc/s, and has been designed for bench operation, is the first unit in the new range. The equipment is housed in an aluminium cubicle and is self-contained, with its own automatic resetting process timer and an overload relay to protect the oscillator



Induction heater for bench use

valve. Provision is made for remote control, and a pulse is available at the end of the heating cycle to initiate quenching or any other operation required. The oscillator valve and coil are water cooled, using 1·5 gallons per minute, with a flow switch in the supply to switch off the equipment and protect the valve from overheating should the water fail. Operation is from a three-phase supply, 360V–460V, 50 c/s, with a full-load consumption of 6·1kW

Training of Engineers

By EWEN M'EWEN M.Sc. (Eng.), M.I.Mech.E.

Recent articles and correspondence in THE ENGINEER *have expressed concern about the training of Engineering Designers on which the author has expressed views in* THE ENGINEER (*August* 13, 1954). *Some of the contributions to this discussion have gone outside the limits of training for design and have touched on the more general question of training engineers of all types. This topic has certainly led to as much heartburning and controversy as any other, both in the United Kingdom and the U.S.A., usually with a premise that insufficient engineers are being trained. From this discussion in the Press and Parliament has emerged the Dip. Tech. scheme and the Colleges of Advanced Technology, the expansion of the Engineering Departments in some of our Universities, and a renewed interest in improving training schemes for the new entrant into industry, whether a potential professional engineer or a potential technician or craftsman. But the author questions whether sufficient attention has been given to the content of technological courses as compared with the provision of places.*

THERE is a deplorable tendency in Universities to take up an attitude of simon purity and to despise work that has practical utility on the grounds that this is not of "University standard." There is a notable exception in the Faculty of Medicine which has achieved the feat of being utilitarian and academically acceptable; moreover, it has at the same time achieved a higher standard of pay than any other Faculty. True, it took a long time to bring this about, but to-day it is accepted as of right, and nobody suggests that only research specialists should go to University Medical Schools while G.P.s are given a more practical training in sub-University "Colleges of Advanced Medicine." It is pertinent to consider what the Medicals have that the Engineer has not got.

One of the important points is that medical staffs of Universities practise medicine! A man could not become Professor of Surgery without having proved himself a notable surgeon and continuing to act as such in the Teaching Hospital: a Lecturer in Orthopædics becomes one by practising his speciality and his teaching is almost an old world craft master-apprentice relation with real cases. But you can become a Lecturer in Engineering without ever having achieved anything in engineering, and you need never do any more engineering, particularly if you have a facility for doing a highly theoretical piece of "research" with no conceivable practical application: this should, of course, preferably be highly mathematical. The mathematics must be right, but the assumptions... there you can really let yourself go!

The Medical Departments are not too proud to have part-time specialist lecturers and clinical teachers: they try, very successfully, to mobilise the best available talent, full-time and part-time, with which to build on the foundations of the preclinical work taught by full-time anatomists, physiologists, &c. Why cannot we do the same in engineering? One reason has already been touched upon—there is a tremendous difference in emoluments; and, regrettably, in status.

Whilst in no way wishing to detract from the eminence medicine has reached, the rise in health is in no small part also the work of the engineer—waterworks, sewage, refrigeration, ventilation, illumination, transport, have all contributed to our better health; in addition, engineering produces wealth and raises standards of living generally which must also make the medical task easier. The status of the engineer should be on a par with that of the surgeon.

It will at once be objected that the part-time specialist could not work in an University Engineering Department. Why not? Given students with a preliminary knowledge of the foundations of fluid mechanics, a specialist from one of the well-known manufacturers of hydraulic systems would bring realism and practical value from a short course in his own field. He would have to be adequately paid for his work, and of course would need the enthusiastic support of his employers; but the engineering industry needs the best possible intake and it would be in its best interests to contribute to that end. It might even result in economies overall owing to a reduction in the length of time required before the young graduate is fully effective in his firm.

Such a system, with adequately paid university engineering staffs, should lead to more interchange between university staff and industry, especially if—as I contend should always be so—the "full time" teacher continues to practise engineering, by consultancy or part-time employment by a local firm. The present conditions in which men become committed to lecturing for life at a tender age is not sound, especially as it is almost impossible to get rid of a mediocre lecturer.

It has been argued that the sort of thing here proposed should be done in Colleges of Advanced Technology, away from the Universities, presumably lest the latter be sullied with men in greasy overalls and the taint of commerce. This would lead to an even greater divorce between engineers and engineering scientists, that gap between the product of the University and what industry requires of a professional engineer to which Sir David Pye has drawn attention. Besides, the practical engineer ought to be part of the University make-up: there is no valid reason why he should be denied the advantages of an University education especially as he is likely in his profession to have a considerable impact on the lives of many people; neither does it harm the rest of the undergraduate body to rub shoulders with him and learn what sort of animal he is. It is pertinent, also, although near blasphemy in some academic circles, to inquire whether the ratio of engineers to engineering scientists should not be much greater in the Universities. Perhaps engineering graduates in industry will in time realise the shortcomings of their training and exert their influence to correct these in their Universities: it is to be hoped that the latter will not be deaf to such suggestions.

We must, of course, make the best use of the engineering graduates we get in industry as well as pressing for them to be better trained. I find myself completely at variance with the idea that a good engineer must be a good detail draughtsman—any more than a physician has to be a good nurse. I doubt the value of much present-day "practical training"—a good engineer need no more be a skilled turner than the company secretary need be a skilled typist. The principal value of practical training is getting to understand the mind of the man of the shop floor, something about organisation and methods, and a general grasp of engineering processes. For these reasons, practical training in college workshops away from industry is valueless: ideally, it should begin long before graduation, in the vacations or before going up. It is astonishing how many undergraduates in their final year blithely design things which they have never seen; indeed, too many have never even been inside an engineering works. It is essential for the budding engineer to grasp that engineering is more of an art than a science, not least the art of compromise. The problems are not capable of unique correct solutions by the application of the principle of elasticity or thermodynamics: there must be a balance between manufacturing, service and design considerations, material and tooling availability, and straight commercial and economic aspects. Industry has to make these judgments and it is there only that the technique can be learnt.

So far, this discussion has been concerned principally with the graduate engineer: much of what has been said applies, *a fortiori*, in technical colleges where salaries and teaching loads aggravate the problems of attracting adequate staff quality. Again, the same remedies would produce results—and the overall bill to the nation would be negligible in proportion to the benefit obtained. There is much talk about falling behind the Russians in engineering training: technological skill properly utilised is prerequisite to the survival of this country.

Orrin Power Station

THE North of Scotland Hydro-Electric Board has brought into commercial operation the Orrin power station in Ross-shire. The station contains one 18MW generating set operating under a gross head of 728ft, which has an estimated annual average output of 76,000,000 units. The new power station is built of pink sandstone from Tarradale Quarry, Muir of Ord; it is situated on the shore of Loch Achonokie, the reservoir formed by the Board's Torr Achilty dam.

The Orrin Scheme involved the construction of two dams in Glen Orrin forming a reservoir 5 miles long to provide storage of over 2000 million cubic feet of water; a concrete lined pressure tunnel 3¼ miles long; and a steel pipeline leading down to the new station. In addition there are 6 miles of concrete pipe aqueducts to collect water from adjacent rivers. The total catchment area utilised by the Orrin scheme is 54 square miles. The output from the station is fed into the 132kV Highland grid. A Borland fish pass is incorporated in the dam.

The civil engineering consultants for the scheme are Sir Alexander Gibb and Partners whose architects are also responsible for the architectural treatment of the various structures. The mechanical and electrical consultants are Messrs. Merz and McLellan. The main contractor for both dams was Duncan Logan, Ltd.; for the tunnel, Whatlings, Ltd.; and for the pipeline, the North British Locomotive Company, Ltd. The 18MW alternator was manufactured by Bruce Peebles and Co., Ltd.; the Francis turbine by the Harland Engineering Company, Ltd. The steel linings used in the fish pass were supplied and erected by P. and W. MacLellan, Ltd., and the hydraulic control equipment by Glenfield and Kennedy, Ltd.

LITERATURE

Book Reviews

Statistics of Extremes. By E. J. GUMBEL. Columbia University Press, New York, and Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 120s.

THIS is a mathematical textbook of immediate theoretical importance to engineers and of practical value in the study of such extremes as floods and droughts, the endurance of materials (fatigue), the loading of civil engineering, naval and aircraft structures, and of variables encountered in such allied subjects as climatology and economics.

Many engineers have made the acquaintance of " normal " distributions (or skew distributions which can, by a logarithmic transformation, be made " normal ") and have studied Gaussian statistics which are preoccupied with averages and frequent events. In many cases of practical importance, however, the mean is of little importance : rare occurrences of extreme values are decisive in design. Professor Gumbel states the aims of a statistical theory of extremes to be the analysis of observed extremes and the forecasting of future extremes. It is clearly essential for this purpose that the distribution from which extremes are drawn remains constant in time (or space) or that any variations in time (or space) are capable of elimination i.e. of definition in such a way that variations may be allowed for in the analysis. Another condition is that the statistics included in a sample should be independent, and here the author has the reader's intuitive agreement to the proposition that very rare events are much more likely to be independent than the more frequent values which lie closer to the mean.

In his first chapter he at once comes to grips with the notion of the " unlimited variate." One of the opponents of this notion, at the recent meeting of the Institution of Civil Engineers on the estimation of maximum floods, appealed to the engineer's common sense and illustrated the idea of physical limits by a homely analogy. The weight of eggs varies in what appears to be a random manner, yet there must be a physical limit : " a hen cannot lay an egg bigger than itself." Dr. Gumbel's denial of the existence of an upper or lower limit is phrased as an affirmation that the probability of occurrence of extreme values differs from unity (certainty) or zero (impossibility) by an amount which can be made as small as we wish.

The " tools " introduced in the first chapter include the intensity function, the return period, and probability papers (with which are associated the problem of the plotting position). This will be studied with especial benefit by engineers who usually prefer graphical to analytical representation.

Chapters 2 to 5 are devoted to the mathematical consideration of the problems of extreme values. Chapter 6 contains numerical examples on flood flows in rivers, on such meteorological variables as atmospheric pressure, temperature and precipitation, and proposes methods of dealing with the problems of landing and gust loading of aircraft, of oldest ages in human populations, of the breaking strength of engineering materials, of break-down voltage (dielectric strength), of wave-induced stresses and motions in ships, and even of the origin of alluvial deposits.

Chapter 7, dealing with limited distributions, introduces the treatment applicable to such phenomena as wind speed (which by definition is never negative). It also quotes certain examples of flood statistics which seem to be better described by the second (" Fréchet ") asymptote than by the first (" Gumbel ") asymptote, and states that only experience can show which of the asymptotes will give the best fit for any sample. Droughts, or annual minima of river flows, are shown to be capable of description by one or other form of the third asymptote, according to which the limit is either zero or a positive value, depending on the sample. Fatigue failures are again described in terms of the third asymptote, and the number of cycles below which no failure can occur is statistically confirmed to be a function of the amplitude of the stress reversal : it may be zero, or it may be a certain limiting positive value. The eighth chapter deals with the range, i.e. various functions of extremes, and quotes some climatological examples.

The book is completed by a Summary, a Bibliography of approximately 500 publications from ten or more countries, and an Index. It is excellently produced. The author writes in a clear style, and uses an occasional touch of humour to lighten the considerable burden which his treatment inevitably imposes on a non-mathematician. At the same time, he clearly possesses a good deal of sympathy with the engineer's problems and, wherever possible, refers to the applications of his theory, several of which he has in recent years described in British publications.

Physical Laws and Effects. By C. F. HIX, Jr. and R. P. ALLEY. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 64s.

THE title of this volume appears first in the list of the General Electric Series written for the advancement of engineering practice and published by John Wiley and Sons, Inc. This priority is no less than due to the conception of the authors, which is simply that if engineers are to solve the fresh problems that are arising more and more frequently, they must attempt them from first principles and not by rearranging their collections of proprietary components. Hence designers need to know what are the properties of matter and energy, and this book is offered as a compilation of many of the phenomena which can be applied by engineers. It is not intended to be complete, as is clear when it is seen that one of the most potent agencies, if not the most potent agency of all, is accorded the last and least of the fields of science :

"PSYCHOLOGY
Purkinge Effect
Weber-Fechner Law."

However, the importance of the undertaking is not reflected in the quality of the publication. One finds a voltage plotted along a scale of miles, and a line dividing liquid from gas extended beyond the critical point : the printers use a symbol " ν " which is indistinguishable from " y," and treat roman and italic faces as interchangeable. The reader of the opening section, " A Use for the Compilation of Laws and Effects " by C. Frank Hix, Jr., may, however, be prepared for such curiosities, since he will have been told without comment that " Galileo described the speed of a falling body as proportional to time squared."

In the Preface it is mentioned that the descriptions given are intended to be as cryptic as possible. It is unlikely that the text will fall short of the requirements of any engineer in this respect. For instance :

" Cosmic rays are highly penetrating radiations which originate outside the earth and consist of photons, electrons, neutrons, protons, and other particles."

" Because fission liberates a relatively large amount of energy, the process is rather useful."

" *Avogadro's Law.* Equal volumes of all gases at the same temperature and pressure contain the same number of molecules, which for a mole of gas at standard pressure and temperature is $6{\cdot}023 \times 10^{23}$."

" For . . . a frequency of 1 radian/second . . . ."

Proceedings of the Third Regional Technical Conference on Water Resources Development in Asia and the Far East. United Nations, Bangkok. H.M. Stationery Office. Price 12s. 6d.

A UNITED NATIONS body known as the Bureau of Flood Control of the United Nations Economic Commission for Asia and the Far East has organised three conferences in the past eight years, the most recent being at Manila, the Philippines, in December, 1957. The usual conference procedure was not followed on this occasion. Comprehensive reports were sought from the various countries in the region, covering four specific topics, and one " background " paper covering each of these topics was then prepared by the Bureau for discussion at the conference. These papers and the discussions they evoked are published in the present volume.

The five main topics are as follows : current programmes for the development of water resources ; basic hydrological data with emphasis on deficiencies ; manual labour and its more effective use in competition with machines for earthworks ; and the relative advantages of constructing river valley projects by governmental agency or private contract.

Books Received

Theory of Beams. By T. Iwinski. Pergamon Press, Ltd., 4 and 5, Fitzroy Square, London, W.1. Price 21s.

Who's Who in Trade Agreements, 1958. Gordon Rayment and Co., Ltd., 87, Chancery Lane, London, W.C.2. Price 40s.

Man the Maker. Second Edition. By R. F. Forbes. Constable and Co., Ltd., 10, Orange Street, London, W.C.2. Price 30s.

The Physical Metallurgy of Magnesium and its Alloys. By G. V. Raynor. Pergamon Press, Ltd., 4 and 5, Fitzroy Square, London, W.1. Price 75s.

Progress in Dielectrics. Volume One. Edited by J. B. Birks and J. H. Schulman. Heywood and Co., Ltd., Carlton House, Great Queen Street, London, W.C.2. Price 70s.

Association of Supervising Electrical Engineers Year Book and Technical Guide, 1958–59. Association of Supervising Electrical Engineers, 23, Bloomsbury Square, London, W.C.1. Price 5s.

Stoff-und Wärmeübertragung in der Chemischen Kinetik. By D. A. Frank-Kamenetzki. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, German Federal Republic. Price DM.28.50.

British Instruments Directory and Buyer's Guide, 1959. Scientific Instrument Manufacturers' Association. United Science Press, Ltd., Boswell House, 9, Gough Square, Fleet Street, London, E.C.4. Price 42s.

Isambard Kingdom Brunel

A REAPPRAISAL*

By FREDERIC NEWHOUSE, M.I.C.E.

Isambard Kingdom Brunel, the author remarks, "has been praised and belauded by many distinguished people to the point of being called one of the greatest engineers of all time." In this article a truer assessment is attempted. After studying Brunel's real achievements, the author concludes that "he had energy, courage and imagination in abundance, but lacked balance, judgement and the faculty of criticism, especially self-criticism," and that he was a great personality "but lacked the essential qualities of an engineer."

ISAMBARD KINGDOM BRUNEL died on September 15, 1859. As he has been praised and belauded by many distinguished people to the point of being called one of the greatest engineers of all time, the Centenary offers a suitable occasion for assessing his work. What did he do that surpassed the achievements of many other engineers in the past century ? He built bridges which were as big as anything built before his time, many of which are still standing, some deserving high praise, but he also built some which were quickly rebuilt or hustled out of sight, a thing that might (and does) happen to any engineer. He built the Great Western Railway (broad gauge) and three steamers, which are discussed below, and he was also consulted on many matters.

He is praised by nearly every biographer for his wonderful "attention to detail." What do they mean by this ? First and foremost, his artistic instinct urged him to spend much time and skill in making the designs for the beautiful ornamentation which adorns some of his bridges and tunnel portals. That is something for which to be truly thankful to-day, when a building has to look like a packing-case on edge and a tunnel portal like a large rabbit-hole in a hillside. Presumably Brunel also devoted attention to such boresome details as the actual stresses, necessary dimensions and methods of building of his structures, though facts do not always support this idea. There were occasional lapses in his designs, but as Brunel insisted on doing everything himself, according to his biographers, it is not surprising that errors and omissions were frequent, causing many disasters. He is credited by many of his contemporaries, and all his biographers, with a wonderful personal magnetism which enabled him to turn indignant critics into enthusiastic supporters after quite a moderate oration or exposition of his case. He created a mystique about himself, and became legendary even in his lifetime. He was no Hitler, but not unlike Mr. Billy Graham, apparently. So far, nothing emerges to justify a high place as an engineer.

Brunel was a man of outstanding courage and determination. He worked for as much as twenty hours a day, not merely in emergencies, such as the breaches in the Thames tunnel, but for weeks and weeks on any scheme as, for instance, the survey for the Reading-Bristol section of the Great Western Railway. The reason for this appears to be that he was unable to find and keep reliable assistants. He quarrelled with collaborators, till he found that their help was indispensable, but he abused his assistants in an intemperate manner, of which, in all innocence, an ardent devotee, Mr. Rolt, gives an outstanding example.[5]† Brunel, it appears, was ticking off a subordinate, not as a prelude to the sack, but just to warn him to do better. Mr. Rolt's extract occupies ten lines of printed matter. Its tone is quite intolerable, and shows up Brunel as a ruthless bully. On the other hand,[2] Isambard Brunel, with filial piety, gushes about the "harmony" in which Brunel worked with his assistants ; however, even the son has to hint at certain disadvantages of working under his father. It is sheer nonsense to suggest that Brunel had to do detail survey because reliable surveyors for railways were not available in England at that time, for many hundred miles of railway had been built here recently while hundreds of miles were still being surveyed. The reason Brunel did not employ surveyors to do surveyors' work was, it is suggested, that no one would work for such a tyrannical master while he could get a job elsewhere. While Brunel was busy with things that should have been done by subordinates, the all-important ancillary matters received little attention. The frequent stoppages in his works and ruin of contractors must have been due to bad specifications, bad contracts and neglect of financial arrangements. If the director of a scheme is absorbed in the detailed survey of the land and the ornamentation of the finished work, the intermediate steps naturally lack thought, planning and control. Nothing of the great engineer, so far !

The work on which Brunel started his career, at the age of sixteen or seventeen, was the Thames tunnel, designed and built by his father, afterwards Sir Marc Isambard Brunel, Kt., F.R.S., M.I.C.E. The son showed such energy and courage that he became resident engineer at the age of twenty-one. He was therefore responsible for the adequacy of all details of design and construction. The tunnel, after many warnings, breached badly, flooding all the works. It was then discovered that there was a large hole in the river bed over the tunnel, caused by dredging for gravel, which had removed the overburden of clay. Young Brunel gets much credit for the energy, courage and initiative which he displayed in coping with this disaster, which was largely the fault of his father and himself. Borings, it appears, had been taken and were believed to show clay to the required depth. Many years afterwards, about 1849, Sir Marc Brunel made a long, rambling statement, from which one gathers he admits he knew nothing of geology. The borings in 1822 were, he says, made with defective tools, but he, Sir Marc, knew enough from his practical experience to know his way about. In short, he went on with the work without adequate precautions for during progress of the work many different strata, including sand and gravel, were encountered, while rushes of water were frequent, but Sir Marc and his son went on like bulls in a china shop, without doing anything to forestall the coming catastrophe. It was not till the first really bad breach occurred that they discovered the large hole above mentioned over the tunnel, thereafter taking the necessary steps to staunch it. It is difficult to excuse Sir Marc and his son for omitting to keep an eye on what was being done to the river bed over the place where they were working. No wonder the works were shut down for seven years, and the promoters ruined !

To condole with them on their bad luck and praise them for their subsequent behaviour during the flooding is like condoling with a jerry-builder for putting up an unsafe house, while praising him for rescuing his children from the ruins when it collapsed. If a true view of this early disaster had been taken by the public, the Brunels, father and son, would have had to turn their energies elsewhere ; there would have been no fiasco over the Clifton Bridge, the Great Western Railway and the "Great Eastern" steamer, and other projects, while we should also be without the present Royal Albert bridge over the Tamar, the Maidenhead bridge over the Thames and the portals of the Box Tunnel, though, without doubt, Telford or many others could have produced satisfactory equivalents. Nevertheless, Brunel's charm was such that his devotees included the Duke of Wellington and Royalty, who at last persuaded the Treasury to put up money when the public were backward in doing so and were, indeed, hostile.

The next work to illustrate the futility of many of Brunel's efforts is the Clifton Suspension Bridge, near Bath. In 1829, Brunel submitted four alternative designs in a competition for this bridge. Telford, acting as judge for the promoters, turned them down and submitted a design of his own, which, again, was turned down because of protests from Brunel. Thereafter, a further competition produced twelve designs, including one by Brunel, which was a modification of his first four efforts. He came second in this competition. His violent protests and arguments fascinated and subdued the judges, who then declared his design to be the best and gave him the job, on which work began in June, 1831, or, at least, there was an opening ceremony. The necessary funds not being forthcoming, nothing further was done. During the period 1829–1831, especially after he had been awarded the job, Brunel was busy on "detail," i.e. designing Egyptian style towers for the abutments and cast iron plaques to cover them, but he did not bother to tell his committee that the money they had was quite insufficient for the project. The period 1831–34 was a time of riots and troubles in England, but money again became available in 1835 to start the bridge, which enabled the foundation stone of one abutment

* References to Isambard Kingdom Brunel, the subject of this article, will be as "Brunel." References to his father will be as "Sir Marc Brunel," while those to his son and biographer will be as "Isambard Brunel." The books consulted are given in a list of references at the end of the article.

† See page 107 of Rolt's book.

to be laid on August 27, 1836, five years after the first ceremony. The second opening was somewhat marred by an accident owing to the failure of a "detail," which apparently had not received that attention for which Brunel is famous. The abutment was partly finished in 1840. Thereafter delay was caused by the failure of the contractor, with the loss of much money by the promoters. Their funds were exhausted by 1843, when work stopped. The scheme was abandoned in 1853. Not much credit for Brunel here!

Brunel had maintained that this bridge was his first step on the road to fame, though its construction was abandoned after twenty years' fuss and bother, a little work on the abutments and much wasted money. The extraordinary thing is that in 1860, after Brunel's death, a body of members of the Institution of Civil Engineers raised enough money to build a suspension bridge at Clifton in memory of Brunel. First, this bridge had sets of three chains instead of the two in Brunel's design, the chains having been taken from the Hungerford Bridge over the Thames, which was one of Brunel's less famous efforts, that was being demolished at the time the Clifton Suspension Bridge was being built. Secondly, Isambard Brunel says that the roadway had to be "stiffened" and additional "bracing" provided. Thirdly, the width was reduced from 35ft to 30ft, while, fourthly, no attempt was made to complete the towers according to Brunel's architectural designs. Very little remains of Brunel's bridge; there is just a bridge at Clifton built by his dazzled friends in memory of Isambard Kingdom Brunel, but, nevertheless, generally known as Brunel's famous bridge. No credit here to Brunel, of any kind!

A little insight is given here into the reliability of statements about Brunel's work. In a footnote on page 58 of Isambard Brunel's life of his father[2] he states that three chains had to be used on the Clifton Bridge because there were three on the Hungerford Bridge. On page 60 of the same work, in a description of Hungerford Bridge, he states that there were two chains on each side of the bridge, making four in all. Much of the early testimony about the Brunels, father and son, is similarly contradictory, incomplete and confusing.

The next scheme for which Brunel is famous is the Broad Gauge Railway from London to the West. The broad gauge has disappeared entirely; much of the permanent way he laid out is still used for a narrow gauge line, though only parts of it now form the main line, and these parts have been straightened. Night trains still go by Brunel's northern route via Swindon from Reading to Bristol, but the day expresses go by the southern route straight from Reading to the West Country via Newbury and Taunton, a route that had previously been proposed by Brunel's opponents. The wags of a century ago used to say that "G.W.R." stood for "Great Way Round."

No useful purpose is served by discussing now how nice it would be if there were broad gauge lines all over Great Britain, instead of narrow gauge. The broad gauge should have been discussed by Brunel with his sponsors before they were cajoled in the Brunel manner to finance such a project, which can only be described as "silly" in the light of the fact that the North of England was being covered by narrow gauge lines, of which many hundred miles were already in existence, and many more sanctioned when Brunel proposed his broad gauge. He did not let his sponsors know his intentions till his scheme was safely incorporated by Act of Parliament as the Great Western Railway Company, in September, 1835. The argument he put forward in favour of his broad gauge was so ridiculous that he had to drop it very soon. He never attached any importance to the problem of interchange traffic between the broad and narrow gauge lines, which was one of the main reasons given by a Royal Commission in 1845 for rejecting the broad gauge. This Royal Commission found that at that date there were 1901 miles of narrow gauge and only 274 miles of broad gauge. The first narrow gauge line was sanctioned in 1821 while Brunel's first broad gauge was sanctioned in 1833. Hence, narrow gauge had been built at the rate of 79 miles per annum, while the broad gauge, starting twelve years later, had only been built at the rate of 12½ miles per annum.

Why did Brunel opt for a broad gauge of 7ft 0¼in? Was it perhaps because his father had installed a short railway in Chatham Dockyard (for the transport of timber) of just this gauge? The reasons Brunel gave to the Royal Commission were futile. When, further, he was asked why, when consulted by Continental clients he did not advise a broad gauge, his answer was equivocal.[5]‡

H. G. Wells says somewhere, that in front of every train there is the ghost of a horse drawing a carriage of 4ft 8½in gauge; similarly, before every train on the broad gauge system there was a phantom timber train from Chatham Dockyard driven by the ghost of Sir Marc Isambard Brunel, F.R.S.

The more important details of the broad gauge system, to which, according to his admirers, Brunel devoted so much attention, include the following items:

1. Locomotives. Those built to his design were so bad that they had to be scrapped. Gooch, afterwards Sir Daniel Gooch, made a new design which resulted in the construction of excellent locomotives.

2. Brunel, following his father's practice at Chatham Dockyard, laid his rails on longitudinal sleepers. The rails were bolted to these sleepers, without chairs, the sleepers themselves being supported on wooden blocks, though some authorities say they were supported on ballast only, well rammed. This appears to have been the main cause of the shaking and discomfort experienced by passengers. It is said that on a 7ft gauge, longitudinal sleepers are cheaper than transverse sleepers.

3. Details of the carriage design were neglected, with the consequence that the bearings and the tyres were badly wrong and had to be replaced, thus increasing the discomfort of the passengers and the expense to the railway.

4. Brunel would not adopt the type of rail (Vignoles) that had proved its worth, but designed a special type of his own, of which many miles had to be scrapped later.

5. One-sided stations. They would take too long to describe. The only thing to be noted is that they were soon scrapped as being ridiculous and quite unpractical.

6. He designed carriages to hang low between big wheels. They had to be scrapped because of the difficulty of getting passengers in and out.

These efforts can be described as original genius; but a harsher explanation would have it that they were the results of a fondness for gadgets and overbearing conceit married both to ignorance of basic principles and indifference to details of design.

There was a further effort of "originality" by Brunel, which leads one to think that the so-called hard-headed Victorians were a set of gullible simpletons. Brunel borrowed this "original" idea for an "Atmospheric Railway" from earlier inventors. It consisted essentially of a railway line with a tube up to 20 miles long laid between the lines. The tube was about 15in or more in diameter, in which there was a piston, whose impelling force was a difference of atmospheric pressure on its two sides, produced by exhausting the air from one side. The piston was connected by a rod to the wagons, through a longitudinal slot all along the pipe. This slot was closed by a strip of leather which acted as a valve, opening as the rod advanced and closing behind it. Many pumping stations were built along the projected line, to furnish the necessary vacuum ahead of the piston. Eventually the machinery was sold at great loss, but the total amount wasted on this freak is not now discoverable. The whole set-up seems incredible, but those who are interested in the fantastic can read all about this "Atmospheric Railway" in a paper by Lieut.-Colonel Alexander, R.E., in Volume 69 of the *Royal Engineers' Journal*,[7] while a fascinating account is also given by Mr. Rolt[5] in Chapter 10 of his book. The most extraordinary feature of this bizarre contraption is the list of distinguished engineers and business men who believed in it.

There was an earlier freak of a minor nature, costing only a few paltry thousands. Brunel borrowed an idea for a "Gaz" engine from his father. The engine was a device for producing power by creating a pressure difference between a heated gas and a cooled gas. Details are not readily available, and are not at this date of importance. The whole fantasy was based on Faraday's discovery of the liquefaction of gases. After much time and money had been spent on this gadget, Brunel had to admit failure. The extraordinary thing is that the Admiralty was induced to put up some money (only £200) for the experiments. They are not such an easy mark nowadays! The Brunels spent a lot of time on this device for fifteen years, off and on, at a cost of £15,000. While Beamish,[1] an intimate friend of Brunel, does not mention him in connection with this folly in his book dated 1862, Brunel's son, Isambard,[2] gives equal credit to father and son. (Faraday was one of the sponsors of Brunel for his election to the Royal Society in 1830.)

Through all these failures, Brunel was full of courage and determination to persevere. Through his magnetism he attracted a few able collaborators (chiefly Gooch and Scott Russell), who pulled him through by revising his unpractical schemes so that after having ruined their sponsors, they worked for a few years.

Brunel's efforts as a designer of great steamers must now be considered, the vessels in question being "Great Western" (1340 tons), "Great Britain" (3270 tons), and "Great Eastern" (18,915 tons). Full details of these ships are given in many places, including Rolt's book, which is the easiest for reference.[5]

"Great Western," launched in 1838, was a wooden ship more than twice as big as any steamship previously to cross the Atlantic, though not the first to do so. She caught fire almost immediately on her first voyage, owing to a minor fault in design (a faulty "detail" again). The damage was made good in about eight or nine days, when a second start led to a brilliantly successful voyage, lasting about fifteen days; later, her best crossings took about thirteen days. "Great Western" did sixty-seven crossings in eight years, and then disappears from history, so far as Brunel's biographers are

‡ Page 151.

concerned, though Colonel Alexander[7] says she was broken up in 1857 after continuous service since 1838, less than twenty years. She was built on principles of design laid down by Sir Robert Sepping, Surveyor to the Navy, but Brunel gets all the credit from his worshippers.

His great achievement in big ship design is stated to have been due to his realisation that the volume of a sphere increases as the cube of the diameter, while the surface area only increases as the square. Hence Brunel deduced that the capacity of a ship for cargo (which is proportional to the volume) could increase faster than the horsepower which is required to drive her and is proportional to the surface friction, more or less. There is not much in reality in this theory because of the many other factors involved.

Taking the figures given by contemporaries, and assuming that the term "gross register" means the same as "gross tonnage," it is easy to calculate the relative increase from "Great Britain" to "Great Eastern." The indicated horsepower increased from 1500 in "Great Britain" to 8300 in "Great Eastern," that is, 5·5 times, while the gross tonnage increased from 3270 to 18,915 tons, or 5·8 times.

Though Brunel was able to convince his supporters that a big ship carried more than a little ship, he was not able to show that there was much change in the ratio of indicated horsepower to gross tonnage. As the figures for shaft horsepower and net tonnage are not available, the true percentage advantage due to increased size cannot be calculated, if any. The difficulty of launching, and the world-wide lack of large enough docks, or deep enough harbours, did not bother Brunel or his backers. They all went on to build "Great Britain," more than twice as big as "Great Western," and when she was a horrible failure, went on to "Great Eastern," nearly six times bigger than "Great Britain," and hence able to cause proportionately greater losses to her promoters.

The history of "Great Britain" is one of disaster and ruin. She had screw propellors, invented by Sir F. P. Smith. Screws were used by the Rennie Brothers, in 1838, but not in such a big ship as "Great Britain," the biggest ship that had ever been launched up to that time. She was an iron ship, but Brunel, that master of detail, had not thought of the fact that iron affects magnets and therefore compasses. She was therefore wrecked in Dundrum Bay, Co. Down, while her captain thought she was off the Isle of Man. After the ship had been towed off and repaired, her owners were ruined. It is a curious quip of idolatry that this disaster is considered a proof of the correctness of Brunel's theory of building iron ships, especially as the theories were not Brunel's, but Sir Robert Sepping's. The change made in "Great Britain" when her wreck was rebuilt was a reduction of 50 per cent in her "nominal" horsepower (whatever that may mean) and an alteration in her masts to make her into a three-masted full-rigged ship, steam-assisted; as such, she was able to sail at 10 knots. Thereafter, she made thirty-two voyages in twenty-three years, mostly to Australia, though she also carried troops to the Crimea, and to India during the Mutiny. After being laid up for years she was sold and turned into a sailing ship, till, in 1886, she was so badly damaged in a storm that she was laid up in the Falkland Isles where she was scrapped in 1937.

The above short history leaves out the failures in her early voyages, due to what are called "teething troubles," a euphemism much used, even to-day, for faulty design or careless construction, or both. The whole record cannot be said to redound to the credit of anyone.

Brunel's last great undertaking was to start building "Great Eastern." Details of practically every misfortune that befell this unlucky vessel are given at great length by Isambard Brunel in his lengthy life of his father, published in 1870.[8] To do Brunel justice, he himself never claims more than to have studied what others had done, and to have adapted it to his enlarged scale, whether it was a bridge, a railway or a steamer. For instance, in February, 1854, Brunel says, in connection with "Great Eastern," that he determined on "the mode of construction now adopted of a cellular bottom." One may be sure that he would have claimed the credit for this method of construction, if he could. He discovered that a big ship would carry more than a smaller ship; further, that if a ship were big enough it could carry the coal for a long voyage, hence "Great Britain," and if still bigger, enough for there and back, hence "Great Eastern." Not really world shaking!

We have seen that the Surveyor to the Navy had provided the principles of design for "Great Western" and "Great Britain." The Royal Navy built many iron vessels after 1845. Would not those be the ships that adopted the cellular bottom, which Brunel very naturally adopted and adapted? The whole detail of the design appears to have been left to J. Scott Russell, who, according to Brunel, was one of the first practical men of the day, and had assisted him in "maturing his plans." Scott Russell seems, undoubtedly, to have designed the ship based on Brunel's proposals, i.e. general specification of requirements. This was claimed by Russell at the time, and never queried by Brunel, who, however, was very angry when a London newspaper, in November, 1854, seemed to him to slight his share in the work. Russell blotted his copybook some years later by gun-running to the State of Massachusetts during the Civil War. The Institution of Civil Engineers turned him off the Council for this, which, however, does not impugn his ability or achievements as an engineer.

The contractors for "Great Eastern" were ordered to proceed in November, 1854, and completed the hull three years later. Nobody appears to have thought out the problems of launching this large vessel, nearly 700ft long and 19,000 gross tonnage, so that things were going wrong the whole time—chains breaking, anchors slipping, presses bursting, moorings worthless, &c., &c. Preparations were made for launching on November 28, 1857, but the accidents due to inefficiency made it January 31, 1858, before "Great Eastern" took the water. Brunel admits in a letter to a friend that they had "several assistances from nature to counteract any of our bungling." Rolt says there was bungling over the launching from early in November, 1857, but, dutifully, Isambard Brunel slides over the first three weeks of failure, giving just one more instance of the unreliability of much of the "evidence" about the Brunels and their works. Anyway, the difficulties and delays since 1854 were such that the owners of "Great Eastern," the Eastern Navigation Company, were ruined by January, 1858, when she was launched, and could raise no more funds for completing her. However, some optimists, including Sir Daniel Gooch, formed a "Great Ship Company" late in 1858 to continue the work. Brunel was a sick man by then, who had to go to Egypt for his health for some months. When he returned, in May, 1859, he could do very little more about this great ship, whose troubles were just beginning, though he gave all his time to her (back-seat driving ?). She had paddle wheels, screw and six masts, while Isambard Brunel says the engines were 1000 nominal horsepower for the paddles and 1600 nominal horsepower for the screw. (The relation (if any) of "nominal" to "indicated" horsepower is not known.) Other authorities give the indicated horsepower for each of the engines, but not the shaft horsepower.

However, "Great Eastern" having left her moorings at Deptford on September 7, 1859, for the first time, a week before Brunel died, had a serious accident on her way to Weymouth, which caused her to be taken to Southampton for the winter.

This accident was due to a mixture of carelessness by personnel and designer. It caused several deaths, at whose inquest Scott Russell said he had designed the vessel, though the general idea was Brunel's.

The "Great Eastern" at length sailed for New York for the first time on June 17, 1860. Her bearings were faulty and had to be replaced when she got back to the United Kingdom, which delayed her next passage to America till May 1, 1861, returning in August, 1861. On her next journey, one of her boats broke loose in a gale, smashing one paddle. Brunel had considered this huge ship to tower so far above sea level that waves could never reach her boats—hence the fixed outboard davits. The other paddle then also smashed, while her rudder was damaged, but she got back to Cork. In 1862 she did two more return journeys, but on the third she struck an uncharted rock in Long Island Sound. "Uncharted" seems unlikely! She managed to get back to England in 1863, and was patched up again. This grounding showed the value of her double bottom, for she survived the great hole that was torn in her hull. After three more return journeys, her second owners, the Great Ship Company, were ruined, and sold "Great Eastern" for £25,000 to Sir D. Gooch and friends, who were the bond holders of the Great Ship Company. The ship was immediately chartered for cable laying (for £50,000—not a bad deal for Gooch!) and laid many useful cables. Thereafter there were a few passages to America followed by a shabby period of various activities, ending in the ship being broken up in 1888, less than thirty years after she was launched, having spent her last years as a "show boat" moored in the Mersey.

The following summary outlines the principal facts about the three chief works on which Brunel's fame is based.

The Clifton Suspension Bridge was not built by Brunel, nor to his design.

The Broad Gauge Great Western Railway no longer exists. It was a silly thing to start at a time when the narrow gauge already had a big lead in England.

Brunel's designs for locomotives, railway carriages, rails and stations had to be scrapped.

S.S. "Great Eastern" ruined two companies successively; the principles of his design were copied from the Royal Navy; her construction was accompanied by a maximum of carelessness; she cost nearly £1,000,000 and was sold for £25,000; she laid some cables and did a few more voyages across the Atlantic. She spent her remaining years, as stated above, as a "show boat" moored in the Mersey.

Brunel built many bridges and other works, some of them of considerable distinction, such as the Royal Albert Bridge over the Tamar and the Maidenhead Bridge over the Thames, previously mentioned. Many of Brunel's contemporaries, however, were more than equal to him, while nothing Brunel did entitles him to the veneration accorded him by his biographers. Brunel is not in the same class as Inigo Jones and Wren, or Robert Stephenson, Telford, Trevithick and Rennie.

However, two presidents of the Institution of Civil Engineers have included eulogies of Brunel in their inaugural addresses. They were Sir William White, in 1903, and Sir Allen Quartermaine, in 1952.

In the foregoing account nothing has been set down in malice, but the extenuations of Brunel's achievements by his relatives and friends have been scrutinised. Their writings consist not of technical explanations of the faults and disasters that accompanied Brunel's activities, but of adulation of his charm and magnetism. He had energy, courage and imagination in abundance, but lacked balance, judgment and the faculty of criticism, especially self-criticism. He could charm and persuade princes and dukes, bankers and Treasury officials, but he failed to hypnotise engineers, though he tried hard on Robert Stephenson and Telford, Gooch and Scott Russell. They remained friendly, but unconvinced. Brunel was a great personality, but lacked the essential qualities for an engineer.

REFERENCES

[1] *Memoir of the Life of Sir Marc Isambard Brunel*, by Richard Beamish, F.R.S. (Published 1862.) He was an intimate friend of Brunel, employed on the Thames Tunnel, first as an Assistant, and later as Resident Engineer.

[2] *Life of Isambard Kingdom Brunel*, by Isambard Brunel, his son. (Published 1870.) Isambard was not an engineer. His accounts of the successive incidents do not give technical details of much value, but are full of the energetic activities of Brunel, which seem, however, to be confined to dealing with each succeeding emergency as it occurred, giving little evidence of precautions to prevent recurrence. Interminable excerpts from Brunel's letters and reports.

[3] *Lady Noble*, great grand-daughter of Sir Marc. (Published 1938.) Full of family incident and admiration of her ancestor. Contains little of value from the engineering angle.

[4] *Master Engineers*, by E. Garnett. (Published 1954.) Interesting information about the feelings of the public.

[5] *Isambard Kingdom Brunel*, by L. T. C. Rolt. (Published 1957.) A good biography, giving a full account of Brunel's activities, as consecutively as is possible in such an incoherent career.

[6] *Obituary Memoir of Isambard Kingdom Brunel*, Vol. 19, 1859/60, *Proc. I.C.E.*

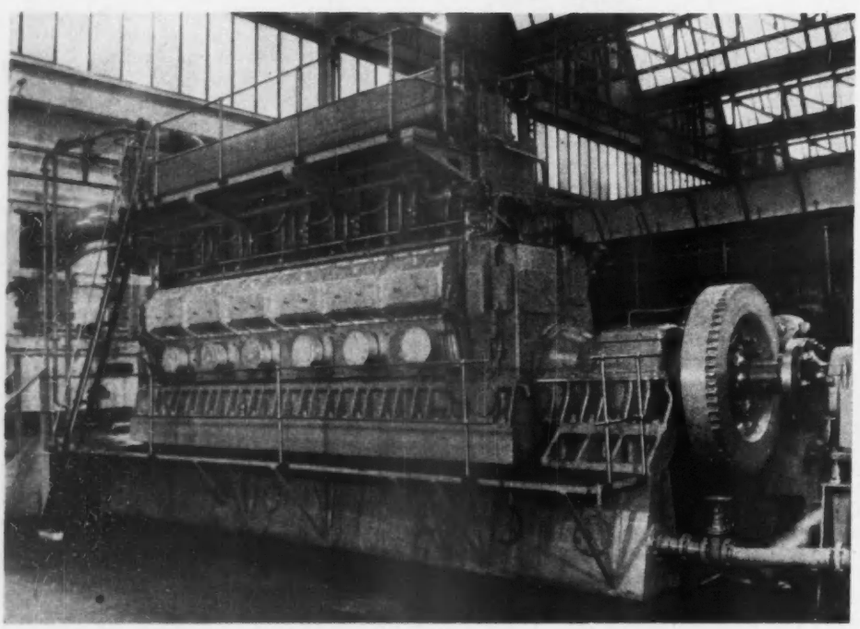
[7] *Royal Engineers' Journal*. Vol. 69, No. 2, 1955. "A Great All-round Engineer," by Lieut.-Colonel Alexander, R.E. Full account of the "Atmospheric Railway."

"Monarch" Class Diesel Engine

To meet the demand for higher power, Mirrlees, Bickerton and Day, Ltd., has designed a new engine based on a specification prepared in collaboration with prospective users. It is planned to produce six, eight and ten-cylinder units of these "Monarch" class four-stroke, vertical, single-acting turbo-charged engines to provide powers ranging from 1600 *s.h.p. at* 200 *r.p.m. to* 4000 *s.h.p. at* 3000 *r.p.m. at a brake mean effective pressure of* 138 *lb per square inch.*

SINCE the introduction of the "K" range of vertical in-line and vee-form engines which are available naturally aspirated, pressure-charged and pressure-charged with air intercoolers, Mirrlees, Bickerton and Day, Ltd., has been engaged in the development of a new engine. This new unit has been designed to extend the range of applications for marine propulsion already covered by existing engines built by the company. Increasing demand for main propulsion units of higher power for installation in distant water trawlers, coasters and tugs was largely instrumental in stimulating the effort to satisfy the demand and to ensure that the engine meets requirements, the specification has been written in close collaboration with representatives of the prospective owners. Three main requirements emerged from the discussions, namely: reliability with maximum availability; long periods of trouble-free running between maintenance periods, and accessibility plus ease of maintenance to allow of a quick turn round. Development of the design has been based on these three fundamentals and upon successful elements of the well-proved "K" engine; however, one major change from previous practice is the removal of the engine-driven lubricating oil, fresh-water and sea-water pumps, in favour of motor-driven units. Another factor influencing this decision was that experience had shown the need to ensure after-cooling of both oil and water.

Cast iron construction has been adopted as against fabricated construction in order to ensure a good degree of robustness, while the scantlings adopted provide for the stresses being kept low and that there is ample margin to cover for any mishandling. Furthermore, the incorporation of through bolts which are pretensioned means that the main frame work is free of tensile loads caused by firing pressures. Other points in the design are the adoption of separate valve cages for air and exhaust valves to assist in the scheme of maintenance, and the fitting of a hydraulic governor which gives a speed range of 5 to 1. Either Brush or Brown Boveri turbo-chargers can be fitted, and the design allows the turbo-charger, together with the air intercooler, to be mounted at either end of the engine to suit the particular installation. Matching tests with both designs of blowers are at present in hand so that the customer's preference can be met. At present it is intended to build the engine in line form as six, eight and ten-cylinder units and a number of orders have been placed already for the six and eight-cylinder models. The first unit made its appearance at the Engineering, Marine, Welding and Nuclear Energy Exhibition earlier this year and a brief description appeared in THE ENGINEER of May 8. A sixteen-cylinder vee engine is projected, but this will be produced initially for industrial purposes. The new range of engines has been designated the "Monarch" class.



Six-cylinder Mirrlees "Monarch" class engine

ENGINE DESIGN DETAILS

As designed, the "Monarch" four-stroke, direct-injection, direct-reversing, vertical in-line, single-acting engine has a bore of 19in by 27in stroke, giving a piston speed of 1350ft per minute at 300 r.p.m., and a compression ratio of 11·35 to 1. The main bearing has a diameter of 15in, the corresponding figures for the crankpin and the gudgeon-pin being 14in and 7½in respectively, while the starting air pressure is 400 lb per square inch. Our illustrations show a six-cylinder engine, and the table records the continuous rated output of the six, eight and ten-cylinder engines, while the accompanying diagram gives the performance curves of the unit.

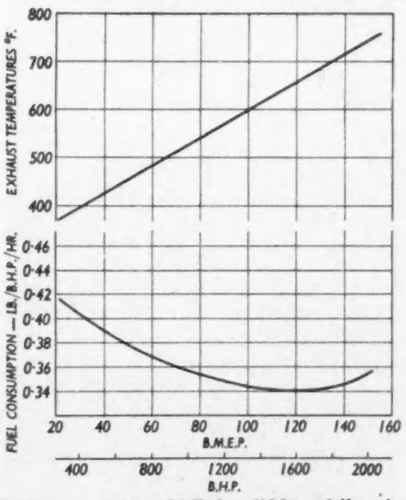
R.p.m.	S.h.p. at 138 b.m.e.p.			S.h.p. at 150 b.m.e.p.		
	6 cylinders	8 cylinders	10 cylinders	6 cylinders	8 cylinders	10 cylinders
200	1600	2125	2665	1745	2310	2890
210	1680	2230	2800	1830	2425	3035
230	1840	2450	3065	1995	2660	3320
250	2000	2665	3330	2170	2890	3610
275	2200	2930	3670	2380	3180	3975
300	2400	3200	4000	2600	3470	4340

The bedplate, column and cylinder-block castings are secured solidly together by long high-tensile steel bolts, which are given a predetermined amount of stretch so as to take up the firing loads. Cast in the base of the deep section bedplate is a manifold from which lubricating oil is supplied through drilled holes to the engine. The camshaft is housed in a separate chamber within the column, which forms the upper part of the crankcase, and the construction is such that the camshaft can be withdrawn athwartships thus facilitating maintenance. Inspection doors are of a size sufficient to permit the removal of pistons and connecting-rods without the need to disturb the cylinder head. On the camshaft side of the engine, automatic spring-loaded explosion doors

Cylinder heads and valve gear

with flame traps are fitted to the crankcase covers. On the column is mounted the cylinder casing carrying the cylinder liners, which are free to expand downwards. The cylinder head, also of cast iron, has two air inlet and two exhaust valves, carried in cages, an automatic air starting valve, a relief valve, maximum pressure indicator cock and fuel nozzle. In addition, there is a decompressor braking valve designed to reduce the time taken for reversals, by bleeding off air on the compression stroke, and is useful when " emergency stop " is called for.

There are four pressure rings and one scraper ring above gudgeon-pin and a second scraper ring at the bottom of the piston, which is of cast iron and oil cooled. The oil is supplied from the engine pressure system via main bearings and the drilled connecting-rod, while the oil return is via sight flow indicators. The crankshaft is machined from a solid steel forging and is carried in white-metal-lined steel shell bearings. The half-coupling, to which the flywheel is bolted, is forged solid with the shaft. A helical gear train from the crankshaft



Performance curves of Mirrlees " Monarch " engine 1840 b.h.p. at 230 r.p.m.

drives the hollow high-tensile steel camshaft, which is fitted with ahead and astern cams and through which lubricating oil is fed to the bearings. Individual pumps, mounted on the column above the camshaft, supply fuel which is passed through two filters through short pipes of equal length to the injectors. A hydraulic governor controls the engine speed and there are control levers for speed selection, starting and manœuvring, the manœuvring shaft being actuated by air-servo cylinders.

During a recent visit to the works at Stockport, we saw one of the new series of engines on test and observed the performance of a six-cylinder engine running over a range of speed at a brake mean effective pressure of 138 lb per square inch. The engine was also run at a brake mean effective pressure of 150 lb per square inch and its manœuvring capabilities adequately demonstrated. Of particular interest to those who have to operate the machinery and those whose responsibility it is to keep time in port down to a minimum was the demonstration of the system evolved for carrying out various maintenance operations, using the tools and appliances specially designed for this purpose.

As mentioned earlier, the piston and connecting-rod can be removed through the inspection door and to carry out this particular job the valves and valve cages were removed and long studs introduced and screwed into tapped holes in the cylinder crown. The studs were attached to a lifting plate and the piston and connecting-rod raised from the big-end bearing and then lowered until the piston rested on a piston sledge, at inspection door level, and the connecting-rod was suspended in the sump. The long studs were removed and the piston on its sledge was levered through the inspection door, over a roller fitted to the lower edge of the door, as illustrated herewith. Then the lifting plate was attached directly to the piston crown and both the piston and the connecting-rod, weighing about 1700 lb, were lifted clear within the allotted time of thirty minutes. In similar manner the removal of the big-end bearing was demonstrated and the main bearing caps and shells, all the operations being completed easily within the time estimated. The following table sets out the times for removal and refit of a number of items.

Item	Weight, lb	Removal, minutes	Refit, minutes
Valves and valve cages ...	66	30	30
Piston and connecting-rod through crankcase door	1690	30	30
Big-end bearing	532	20	40
Main bearing caps and shells	400	20	40
Cylinder liner	1550	10	15
Cylinder head	2600	50	50

The engines are arranged to burn heavy fuel and to facilitate testing of the " Monarch" class an extension is being built to the works which provides test space sufficient to take three engines. A number of engines are already on order for installation in trawlers and the company considers that the unit is suitable for multiple-unit propulsion purposes. As an example of such an application, it is stated that two six-cylinder engines, coupled to a twin input gearbox, will have an output of 5000 s.h.p. at 300 r.p.m., with a brake mean effective pressure of 150 lb per square inch on an all-up weight of 190 tons.

Piston on sledge being withdrawn together with connecting-rod through crankcase door

Technical Reports

The Influence of Drag Characteristics on the Choice of Landing Approach Speeds. By D. Lean and R. Eaton. A.R.C. Current Paper No. 433. H.M. Stationery Office. Price 4s.—A study has been made of the lift-drag characteristics of nineteen jet aircraft which have minimum comfortable approach airspeeds that are fairly well established. On about half these aircraft drag effects, which determine speed stability, were stated to limit the approach airspeeds, though there was naturally some lack of unanimity as to the level of the effect which could be classed as tolerable. Limiting values of speed stability are proposed for the three types of landing approach used for carrier, airfield and instrument landings. The speeds corresponding to these stability levels are in fair agreement with those actually used, even for those aircraft whose approach speeds were not primarily limited by drag effects. It is considered that drag effects must be taken into account in estimating approach airspeeds, and that this process materially improves the prediction of approach speeds for the latest types of aircraft. Further data should be collected and analysed in order to confirm or modify the form or level of the proposed limits.

The Conversion of Ionospheric Virtual Height-Frequency Curves to Electron Density-Height Profiles. Department of Scientific and Industrial Research : Radio Research, Special Report No. 28. H.M. Stationery Office. Price 3s. 6d.—Penetration frequencies of radio waves in the ionosphere are regularly tabulated and circulated by agencies controlling ionosphere sounding stations. From these reports knowledge is gained of electron densities at the peaks of the reflecting layers, but for detailed investigation of the physics of the ionosphere it is desirable that the variation of electron density should be studied at other heights. It has been known for a long time that the shape of the $h'(f)$ curve depends on the way the electron density N is distributed with height h, but it is only recently that the calculation of $N(h)$ curves from the $h'(f)$ curves has become practicable. This has now been done with a computer, using the $h'(f)$ curve as input data and producing the $N(h)$ curve in about twenty seconds. The method described is a general one, but the report is written with specific reference to the calculation designed for a Ferranti " Pegasus " machine.

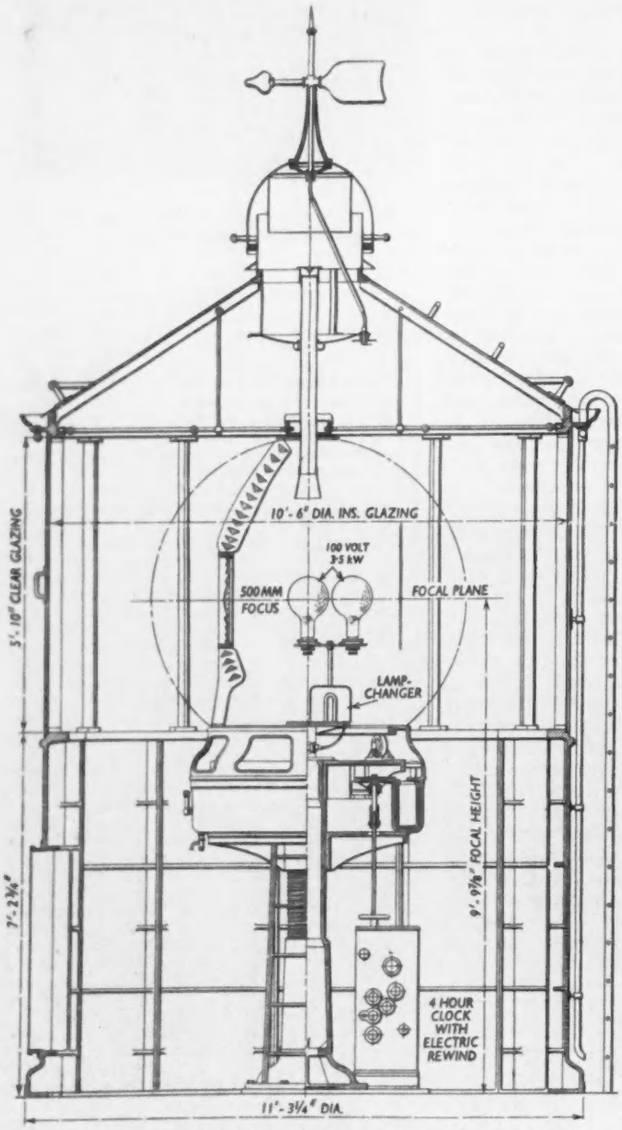
Powerful Lighthouse Equipment for India

A lighthouse equipment of over 5,000,000 candlepower being built by Stone-Chance, Ltd., for the Government of India, is one of the most powerful lights constructed by the firm for many years. In this equipment the light from a 3·5kW lamp is condensed into two beams so arranged that as the lens assembly is rotated at 3 r.p.m. a double flash is transmitted every twenty seconds. In clear weather this flash will be visible at a distance of some 45 sea miles.

A LIGHTHOUSE equipment, now in its final stages of works erection at the new factory of Stone-Chance, Ltd., Lighthouse Works, Gatwick Road, Crawley, Sussex, has a beam intensity of 5,100,000 candelas, and when installed will have a range of over 45 miles in clear weather. This equipment has been made for the Dwarka lighthouse in the mouth of the Gulf of Kutch, Saurashtra State, India, some 350 miles north of Bombay. When in service the new light will be one of the most powerful in Asia.

Our illustrations show the main parts of the equipment assembled at the maker's works and the drawing we reproduce shows the final assembly on site. The optic or lens array is rotated at 3 r.p.m. and is designed to transmit a double flash every twenty seconds. This lens array is a Third Order (500mm focus) design and the illuminant is a 3·5kW, 100V lamp. A standby lamp is mounted on the same bracket as the lamp in use and is brought into effect upon failure of the service lamp. The automatic lamp exchanger device fitted for this purpose brings the standby into focus immediately it comes into operation.

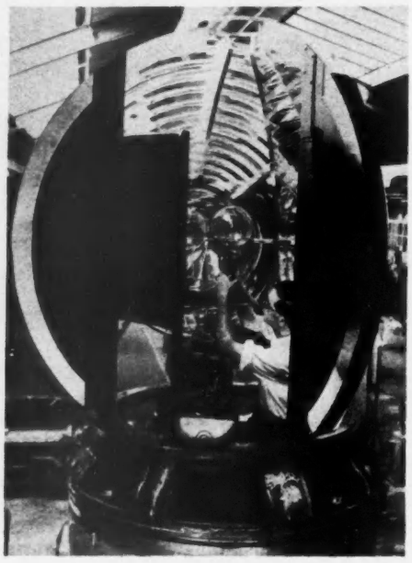
The lens array comprises two lens panels, each set at 128½ deg. and having their axes at 90 deg. The remaining 103 deg. arc of the assembly is provided by two metal blanking screens, which give the long eclipse period for the light. One of these screens is hinged to provide a door which can be seen open in one of the illustrations.



Section through lantern showing optical arrangement, pedestal and rotating mechanism

The optical assembly of the light is mounted on a pedestal through a conventional mercury bath "bearing," which ensures free almost frictionless rotation. This pedestal and the drive mechanism are mounted on a common baseplate and the whole assembly is enclosed in a 10ft 6in diameter lantern. The lantern has a lower portion or murette built up of cast iron segments, bolted together. A section above the murette is glazed with ⅜in thick curved glass panels and the lantern roof of copper sheets is surmounted by a dome ventilator. A series of louvred pockets round the lower part of the murette provide air inlets which can be adjusted as needed.

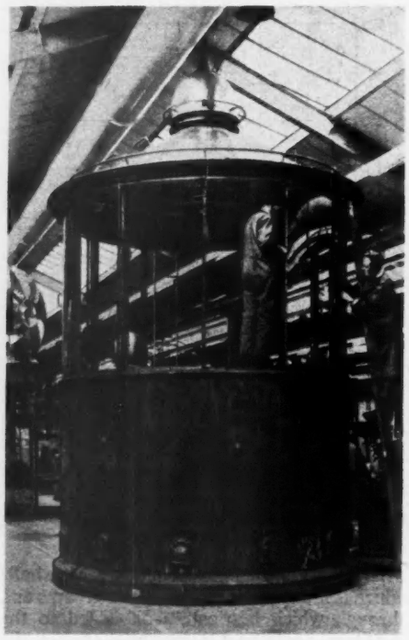
The lens array is rotated by the weight-actuated clockwork mechanism shown in one of our illustrations. The weight cable drum of this mechanism is rewound every four hours by an electric motor, the current supply of which is switched on by the weight contacting a trip switch at its lowest point in its guides and switched off by a second switch at the top position of the weight. Bevel gearing through which the motor drives the cable drum is coupled to the drum itself by a spring-loaded friction clutch to prevent damage to the gearing should the cut-out switch fail to act. In the event of a failure



Optical apparatus with blanking screens which provide the long eclipse period. The automatic lamp changer can be seen in position within the lens

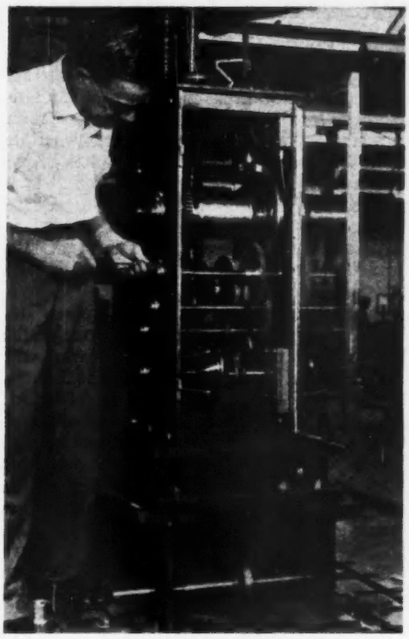
of the winding gear an alarm bell is sounded. All parts of the gear train are designed to be quickly removed and replaced in daylight hours to ensure that the light is serviceable without fail at night. The shafts of the gearing and governor are all mounted on ball races carried in screwed housings on the cabinet sides to facilitate maintenance and repairs. The final drive to the lens array is transmitted through a vertical pinion shaft meshing with a gear ring in the base.

As already mentioned, the rotating section of the equipment is supported on a mercury



The 10ft 6in diameter lantern for housing the optical apparatus

bearing and it is maintained centrally by a series of horizontal rollers round the sides. In the unlikely event of the mercury level falling, rollers are arranged round the bottom of the assembly to register on a support path. About every five years it is necessary to renew the mercury and clean the support assembly, and for this purpose the support column of the pedestal has a heavy square section thread machined round its upper part. Through this threaded section of the pillar the annular trough containing the mercury can be lowered to leave the lamp supported



Optical apparatus weight actuated clockwork drive mechanism

on its roller path, whilst maintenance work is easily completed in daylight hours.

The lighthouse will normally receive its power supply from the mains and an a.c. mains regulator is provided to maintain the voltage at 220V, $\pm 2\frac{1}{2}$ per cent, when the incoming voltage fluctuates between 220V, ± 15 per cent. A control cubicle of sheet steel mounted on the wall of the lantern accommodates all the relays and fuses for the winding and illuminating equipment. Duplicate transformers are provided to transform the 220V mains or standby supply down to 100V for the lamp. A standby diesel generator set provided has a six-cylinder, cold-starting engine, developing 30 b.h.p. at 1000 r.p.m. on a twelve-hour rating. This 10kW set automatically comes into service in the event of a mains supply failure to keep the lighthouse in full effective operation.

An equipment of interest now being made at these works is the recently developed "Power Beam" beacon for use at sea and on air routes. This beacon has a two-tier lens system comprising six half-panels of unplasticised clear "Perspex" welded together. The two lens tiers are superimposed and they can be set to provide either six or twelve separate beams. To provide the required character combinations, blanking screens, colour filters or spreading panels can be fixed in front of the panels.

The speed at which the beacon can be rotated can be one revolution every ten, twenty or thirty seconds, and it is fitted with an automatic lamp changer having four lamps.

Re-Motoring of a Strip Mill

In the removal and replacement of the motor drives of the continuous strip mill of Richard Thomas and Baldwins, Ltd., Ebbw Vale Works, some 1500 tons of equipment was removed and the new plant installed in nineteen days. This work, for which The General Electric Company, Ltd., was the principal contractor, started at 9 a.m. on August 1, and the mill was ready for an experimental start, running light, on August 19, one day ahead of schedule.

NOTES have been received of a fine example of planning and effective co-ordination in a major re-equipment scheme which took place in carrying out the re-motoring of the continuous strip mill at the Ebbw Vale works of Richard Thomas and Baldwins, Ltd., at the beginning of August. This work, which involved the removal of 1500 tons of machinery and its replacement by new equipment, was started at 9 a.m. on August 1. It was completed one day ahead of schedule on August 19, when the mill was ready for an experimental start running light. The main contract for this scheme of electrical re-equipment was placed with The General Electric Company, Ltd., in 1957, the consultants for the electrical and civil work being McLellan and Partners, who were assisted on the civil side by W. S. Atkins and Partners. The other contracting firms involved in the work were Davy and United, Ltd., Associated Electrical Industries, Ltd., and Sir Robert McAlpine and Sons, Ltd.

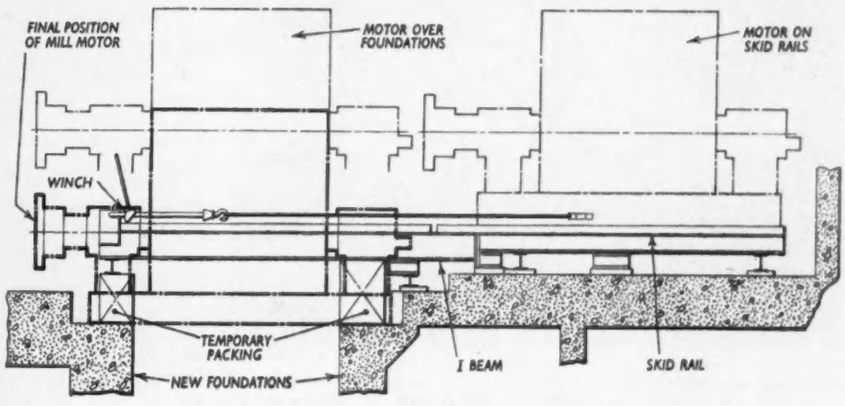
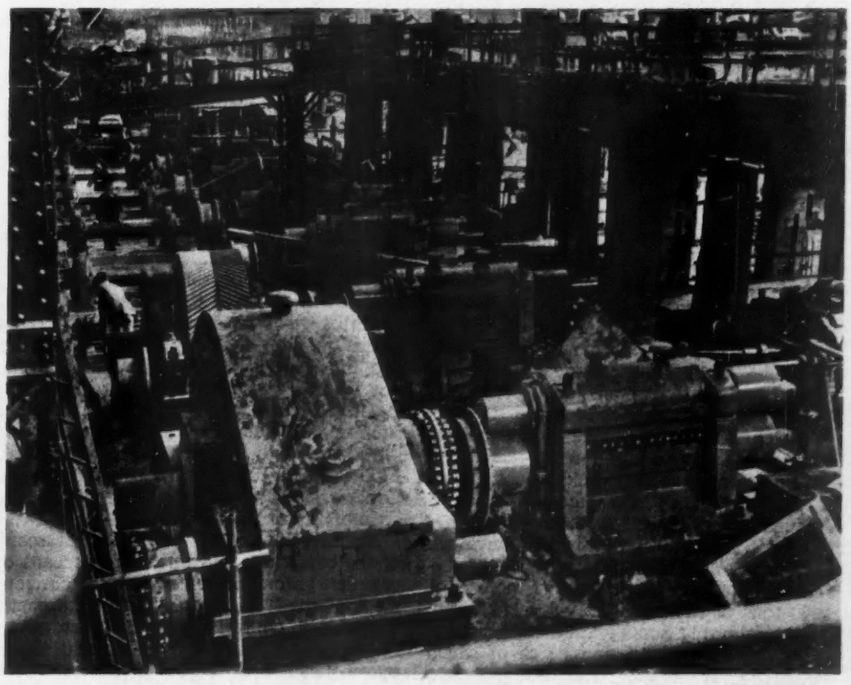
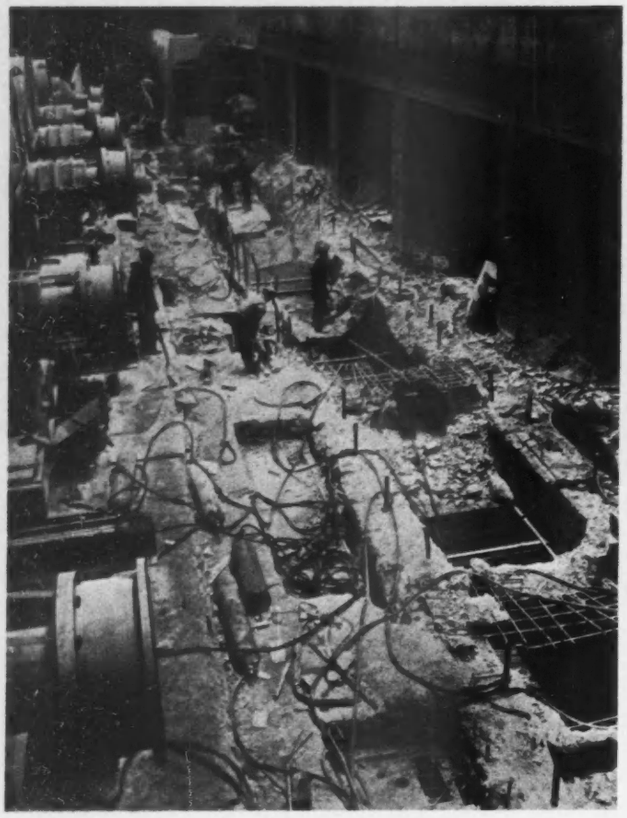


Diagram showing method of installing the new motor drives

The main components of the new equip-



Gearboxes and pinion housings in position at the rear of the six-stand mill, ready for lining up, at the end of the first week of the operation



The motor room twenty-four hours after the start of the operation, when the old motors had been removed. Foundations are being prepared for the new motors

ment to be installed for the mill included the drive motors, rectifiers and transformers, circuit breakers, copper busbars and cables, mill control equipment, protection equipment and instrumentation. As it was required to run the mill up to the last moment before changeover, it was necessary to complete the installation beforehand with the sole exception of substituting the new motors for the old. Under the scheme evolved the new and larger motors were to be erected on the motor room floor behind the existing drives for preliminary running tests. Preparations for the new drives necessitated the moving of two of the three motor generators supplying the original mill drives. One of these sets was taken out of commission completely and another removed bodily on to new temporary foundations during the August holidays in 1958. At the same time, all the original stand drive d.c. circuit breakers were transferred from the basement to sites adjoining the motor foundations, and a temporary 500V d.c. system installed. This operation left room for a new 750V main circuit installation and cooling system to be erected and partly commissioned before the 1959 changeover. During May and June this year the new machines were erected behind the existing motors upon temporary bases built up from structural steel sections.

As already stated, the removal of the old equipment began at 9 a.m. on August 1, and in an illustration on this page there can be seen the state of the motor room twenty-four hours later. By that time more than 1000 tons of equipment had been removed. By the following Sunday afternoon, the first of the new pinion housings, each of which weighed some 30 tons, had been put into place, and by the next day all the pinion housings to be renewed on the roughing mills and six-stand finishing line were in place.

As the reconstructed foundations then became available the electric motors, gearboxes and other major items were lifted in. The method of installing the motors can be seen in the diagram we reproduce. For the purpose slideways comprising heavy I-beams, topped by railway rails and supported by twin stacks of packing, were erected across the space between the two supporting walls. Next, the new motors were jacked up to allow rails to be placed between the tops of the temporary bases and the motor bed-plates, these rails being at the same level as those of the slideways. The motors were then traversed into position above their new foundations by winches the cables of which were secured to hauling lugs on the motor baseplates. The operation was completed by lowering the motors vertically on to the new foundations. This was carried out by successive removals of sections of packing whilst a motor was temporarily supported.

The total weight of the motors thus moved was 484 tons, the largest unit weighing 120 tons. The motor baseplates were specially designed to withstand without distortion the abnormal horizontal and vertical forces involved in the move and were also provided with lugs and lifting pads to facilitate the work. Accurately machined and calibrated surfaces near each bearing greatly simplified final lining up and coupling, which was completed on August 19, when the mill was ready for light test running.

It is stated by Richard Thomas and Baldwins, Ltd., that with the new electrical drives totalling some 36,000 h.p., a significant increase in output is expected from the mill. In addition to this work the firm has carried out a large amount of replacement and maintenance work in other areas of its hot mill. In a smaller, but equally concentrated, effort a few weeks earlier, a fourth stand was added to the three-stand cold reduction mill. Last month, also, the first of three 120-ton open-hearth furnaces, being constructed to replace three of 90 tons capacity, was brought into operation, and work is now proceeding on the second furnace.

In the Bessemer department, plans are being made for the adaptation of one of the four converters to " L.D." top blowing, the system of steel-making to be used at the new Spencer Works at Llanwern, near Newport. At present all four converters are equipped for oxygen/steam blowing, which has enabled the department to produce steel rivalling that from the open-hearth department for use in extra deep drawing. Greater economies are expected, however, from this " L.D." system by which oxygen is blown from above instead of through the bottom of a converter.

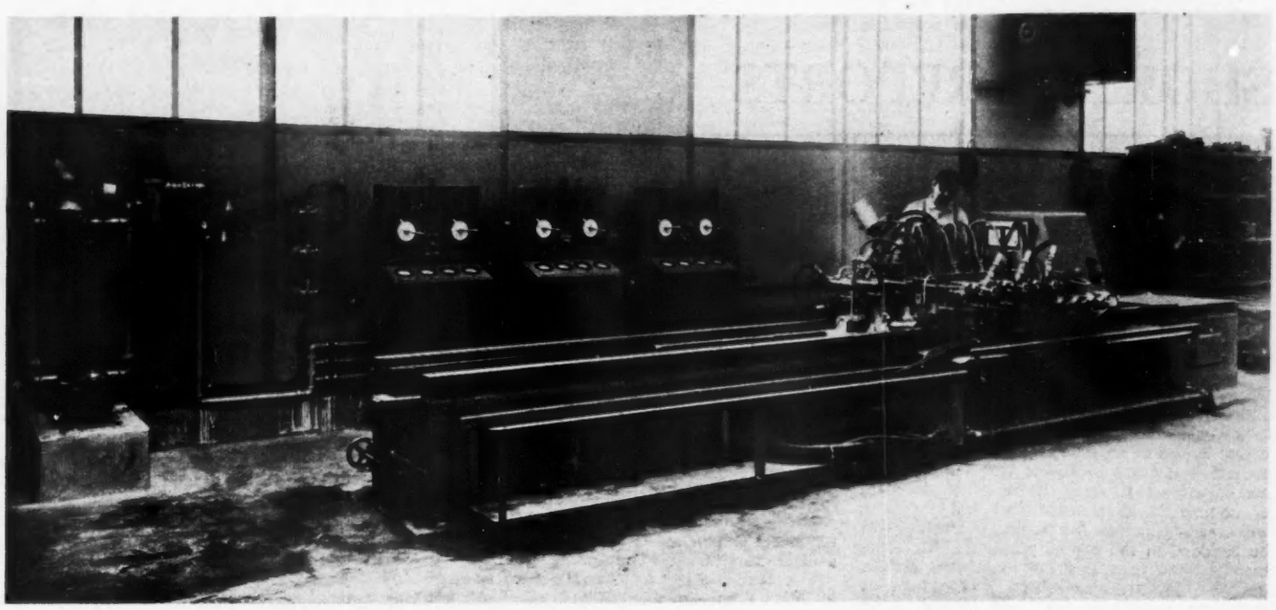
Oxy-Town Gas Flame Hardening

THE system of flame hardening using oxy-town gas developed by Firma. Paul Ferd. Peddinghaus, of Gevelsberg, Westphalia, Germany, has been applied in a steadily widening field of industry over the past ten years. The equipment was first developed by the firm in its own works, to enable the use of relatively cheap and easily available town gas for flame hardening the jaws of drop forged vices which were, and still are, made in very large numbers. The results attained with this original equipment were so successful that the firm decided to develop machines for other applications where a controlled depth of surface hardness without risk of distortion was required. For this purpose a special section was set up at the Gevelsberg works, both to develop equipment and to undertake flame hardening work for other firms. From this time development was rapid and the process was introduced in a steadily widening field of industry in Germany and other countries. The Peddinghaus system was introduced into this country by Surfard, Ltd., Abford House, 15, Wilton Street, London, S.W.1, and was described in our issue of February 29, 1952.

An important step in extending the scope of the equipment and introducing means of complete automatic control was the development of the " Milliscope." This automatic temperature control instrument operates on the principle of an incandescent lamp pyrometer, and through it a constant check is maintained on the temperature of the work at the point of heating. The instrument shows on a dial variations from the preset temperature and it is generally coupled to the machine controls to adjust the supply of gas or vary the speed of work or nozzle traverse to ensure constant results.

A range of universal and standard machines which is now available with a large selection of burners cover the requirements for hardening most sizes of flat, rounded and profiled shapes and gear teeth. In addition special purpose equipment has been developed, frequently using standard components, to suit particular requirements. One such special installation was that at the works of Ruston Bucyrus, Ltd., Lincoln, described in our issue of March 20, 1959.

In the course of a recent visit to the Peddinghaus works we were shown in operation a variety of the special machines which have been developed for hardening gears, shafts, tractor track plates, sprockets, crankshafts and rails, as well as machines of universal design supplied with interchangeable burners and other parts, for handling a variety of shapes and sizes of components. One machine undergoing its tests at the time of the visit was a very large " spin hardening " machine for gears up to 60in diameter and 10in wide, which is illustrated on this page. In this spin hardening method, as distinct from the individual progressive or step-by-step tooth hardening system, the gear is rotated whilst the flames from burners are continuously projected on the teeth and the complete gear is quenched when the hardening temperature has been attained. With spin hardening the gear teeth are hardened right through, whereas in progressive tooth hardening—



Rail hardening machine in operation hardening the ends of rails used for track cross-overs

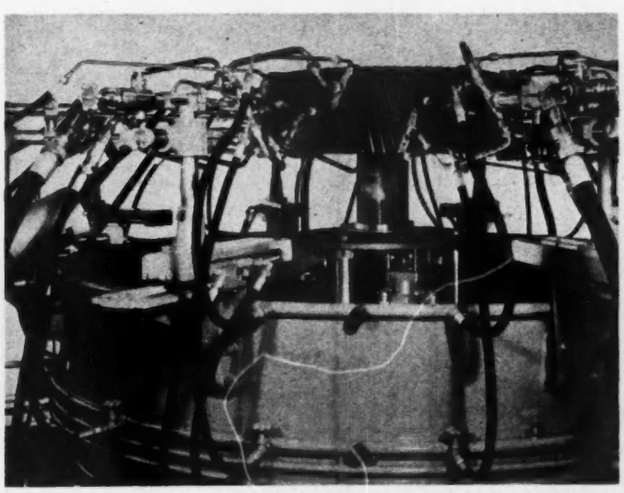
where heating is followed by immediate quenching—the actual depth and zone of hardening can be determined by burner and quenching head design.

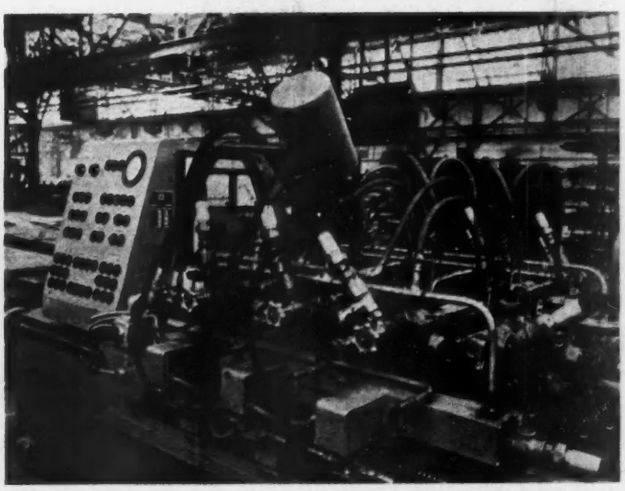
In the large machine illustrated the gear is mounted on a turntable above the centre of a quench tank and the turntable is rotated at 40 r.p.m. by a hydraulic motor during the heating phase. A series of burners adjustably mounted on brackets round the sides of the tank are positioned to direct their flames over the whole gear tooth surface. As the gear rotates and is heated the temperature is recorded by a "Milliscope," and when the required heat is attained the "Milliscope" circuit initiates the quenching cycle. The turntable is lowered rapidly by hydraulic gear to immerse the gear in the oil and the gas supply to the burners is cut off. During the quenching cycle the oil is circulated by pumps through a water-cooled heat exchanger to prevent an undue rise in oil temperature. During the heating cycle a curtain of compressed air directed across the surface of the oil from nozzles round the tank rim prevents contact of the hot gases with the oil surface.

In tests on this machine it was used to spin harden a briquette press ring 330mm wide by 1000mm outside and 860mm inside diameter. It took nineteen minutes to raise the temperature of the ring to 850 deg. Cent., and the quenching cycle also took nineteen minutes. For this heating cycle the gas feed rate was set at 10,100 cubic feet per hour and the oxygen rate at 6074 cubic feet per hour.

Some time ago the firm investigated the possibilities of introducing its surface hardening process for railway wheels and rails with a view to reducing wear in service. It is now being used effectively by a number of Continental railway authorities, and is stated to have promoted considerable economies in extending wheel life and reducing track wear. Particularly successful results have been obtained in hardening the ends of rails used in making up track cross-overs where the rate of surface wear is normally very high. With surface hardened rails on cross-overs the replacement rate has been considerably reduced. The extended rail life has resulted in a complementary reduction in track maintenance costs and the traffic delays incurred in re-laying operations. With the process a rail surface can be hardened up to a depth of about $\frac{1}{2}$in over any required length in accordance with traffic conditions.

The standard machine used for rail hardening can be seen in operation in our second illustration. It comprises a channel shaped bed in the centre of which the length of rail is laid on rollers. A carriage is propelled along the length of the bed by a lead screw turned by a variable speed gear to give a working traverse speed, usually of about 4in per minute. On this carriage there is mounted the complete hardening assembly comprising, in line, two preheating burners, a final heating burner which raises the rail surface temperature to about 940 deg. Cent., and two quenching nozzles. The first quenching nozzle is spaced a predetermined distance behind the final gas burner to give a "soaking" period at the rail. When the cooling jet comes into play at the end of this period the rail surface temperature has decreased to about 850 deg. Cent. A "Milliscope" directed on to the heated area of the rail gives a continuous record of the temperature which can be maintained constant by manual operation of the gas and oxygen controls or automatically if so desired.





(Left) Spin hardening machine for gears up to 60in diameter by 10in wide (Right) Carriage of rail hardening machine with "Milliscope" head directed on to the heating zone automatically controlling machine to ensure maintenance of correct hardening temperature

SHORTER REPORTS

Institution of Mechanical Engineers

In recent years, the Institution of Mechanical Engineers has acquired the head leases of property adjoining its headquarters at Birdcage Walk, Westminster. Plans for developing this property have now been prepared, the additional space providing much-needed additional accommodation for the staff and amenities for members of the Institution. Plans are in hand to enlarge the existing lower meeting hall to seat 130 people under improved conditions and to improve the kitchen accommodation and equipment to enable better service of refreshments to be made. The council is anxious to ensure that the extended headquarters shall meet the needs of members as completely as possible and will therefore welcome suggestions for particular amenities to be included in the overall planning. Members may well be in a position to suggest certain desirable improvements which, if considered at this stage, could readily be incorporated in the plans. Members who wish to put forward suggestions are asked to submit them, in writing, to the Secretary without delay.

The Institution has also directed attention to the change in the day on which ordinary meetings will be held in the forthcoming session. The meeting day is to be Wednesday (instead of Friday) at 6 p.m. The opening meeting of the new session is on Wednesday, October 14, at 6 p.m., when Mr. H. Desmond Carter will deliver his presidential address entitled "The Engineer, Life and Diesel Engines."

Plastics Products

We learn that Polypenco, Ltd., 68–70, Tewin Road, Welwyn Garden City, Herts, has made available a particularly stable thermoplastic. This new product, known as K.51, is a chlorinated polyether derived from pentaerythritol, and possesses an unusual combination of properties for a thermoplastic, including excellent mechanical strength, high temperature resistance, exceptional chemical resistance and extreme dimensional stability.

Polypenco K.51 is inert to almost all alkalis, solvents, chlorides, and inorganic acids; this unusual degree of inertness, together with its mechanical strength and heat resistance, makes K.51 of particular interest to the chemical industry for parts operating under severe corrosive condition. K.51 is also completely non-hygroscopic and possesses excellent outdoor weatherability.

K.51 is a comparatively rigid stable material, having a tensile strength of 6000 lb per square inch and a Rockwell hardness of R100. It has high resistance to deformation under load and very low cold flow tendency compared with fluorocarbons. As a result, finished parts are structurally tougher and more durable than the majority of other plastics. The wear and abrasive resistance properties of this material are also good. Whilst K.51 heat distortion temperature is in the same general range as Nylon 66, it can be subjected to continuous operating temperatures from 120 deg–130 deg Cent. in an oxydising atmosphere. K.51 possesses good electrical insulating properties and as a dielectric it is superior to most thermoplastics, its loss factor being low over a wide frequency range.

This new material is available in a wide range of extruded shapes which are readily machineable into component parts on conventional metal-working equipment.

We have also received particulars, in the form of a brochure, of the firm's "Nylaflow" pressure hose and tubing. The tubing is available in two ratings, for burst pressures of 1000 lb per square inch and 2500 lb per square inch, and the hose, which is reinforced with high tensile strength yarn, has alternative ratings of 5000 lb per square inch and 8000 lb per square inch. The resistance of the hose to flexing and pressure pulsing is quoted. A special grade of tubing is available for use continuously in oxidising atmospheres at temperatures up to 105 deg. Cent., instead of the 82 deg Cent. of normal hose.

Hand-Operated Bascule Bridge of Light Alloy

A canal drawbridge of all-aluminium construction has recently been installed to replace a 60-years-old wooden structure over the Birmingham–Oxford canal at Banbury, and is shown in the illustration. It has been built for the Water Department of Banbury Borough Council, and was designed by Northern Aluminium Company, Ltd., to carry the Ministry of Transport standard load.

The bridge is 10ft wide with a clear span of 9ft 6in. It utilises about 1700 lb of aluminium in Noral B51SWP (BSH3OWP) alloy, fastenings being aluminium-alloy rivets and mild-steel bolts protected with "Duralac." The main longitudinal floor members consist of four 8in by 4in I-beams and two 8in by 3in channel sections. These are capped at the hinge end by two transverse 8in by 3in channel sections bolted back-to-back, and at the opposite end by one 8in by 3in channel section. Extruded corrugated floor planking, 8in wide by $\frac{3}{4}$in deep, is laid across the main floor beams as decking. The handrails consist of $2\frac{1}{2}$in square tubes and round tubing, with a standard "hand-rail" extrusion.

The bridge can be easily operated by hand and is counterbalanced to remain in the raised position when lifted. This was achieved by filling the two 15ft tapered balance arms with concrete. These arms were fabricated from two 6in by 3in bulb channels with $\frac{1}{8}$in cover plates. Hard-rubber blocks are fitted along the sides of the bridge to protect the structure from damage that might be caused by waterborne traffic.

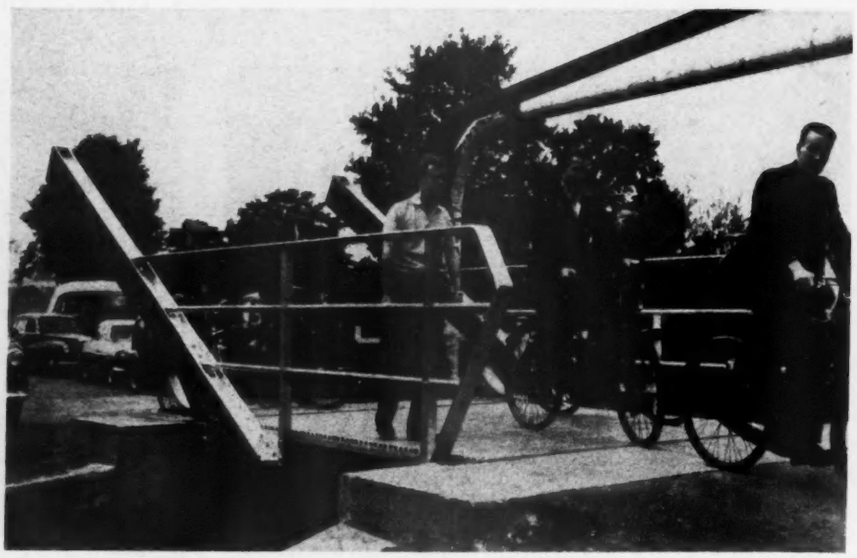
The "hinge" of the bridge consists of two steel I-beams fabricated into quadrants (the near side one can be seen in the illustration) and each being in a steel plate fixed in the abutment. Holes in the lower flange of each of these quadrants engage with studs projecting from each of the steel plates. The two steel quadrants are bolted to the light alloy structure, with "Duralac" protection at the bi-metallic junction. The quadrants are painted with aluminium paint. When the bridge is lowered it rests on a transverse timber cast into the concrete abutment.

Central Laboratory for London Transport

Work has begun at Chiswick on a new two-storey building to house the Central Laboratory of the Research Department of London Transport, whose scientific staff has hitherto been dispersed in various parts of the Chiswick Works Estate. The new premises will have a floor area of 26,000 square feet and will give space for additional staff and new apparatus. Among the facilities to be provided are a cold chamber for low-temperature testing, a screened room for work with a 200kV industrial X-ray apparatus and for gamma-radiography using a cobalt 60 source; heat-treatment furnaces and welding equipment; a pilot plant laboratory; special recording equipment for strain gauge tests; and a fatigue-testing machine for railway car axles. It is stated that the fatigue-testing machine will be the only one of its kind in Great Britain. The machine is being designed and constructed under an extramural research contract at the University of Nottingham. The concrete base on which it will stand will weigh about 10 tons and will itself rest on an anti-vibration mounting independent of the foundations of the building. The machine will be used for investigations into the properties of different grades of axle steels and variations in methods of cold rolling, the objective being to effect such improvements as will virtually eliminate any tendency for the development of fatigue cracks during the service life of the axles.

Experience with a small cold chamber, installed some three years ago in a temporary hut, revealed a latent demand for such equipment. The better facilities which will become available in the new laboratory will further assist in the development of conductor rail de-icing fluids, in the testing of alternative methods of de-icing, and in investigating problems relating to the performance of air-operated and other mechanical and electrical equipment under low-temperature conditions.

London Transport also has small laboratories at its three generating stations, and these will be retained for local requirements.



This light-alloy canal drawbridge spans 9ft 6in. It carries standard highway loading

Vertical Furnace for Gas Carburising

AN atmosphere furnace combining the advantages of pit type gas carburisers with facilities for closed quenching, is now made by the Electric Resistance Furnace Company, Ltd.

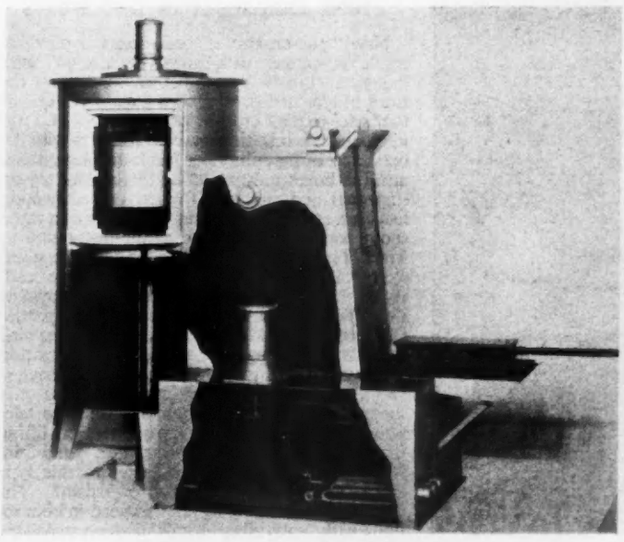
As can be seen from the sectioned model we illustrate, the furnace has a vertical cylindrical heating chamber which is closed at the top and has provision for the insertion of a charge through the base. It can be electrically heated by "Corrtherm" elements or gas fired with radiant tubes. The charge is shielded from direct radiation by a heat-resisting baffle suspended from the furnace roof, or, alternatively, the sides of the charge basket. A large fan, mounted directly above the charge, draws the atmosphere up through the charge and forces it down over the heating elements, ensuring uniformity of heating and intimate contact of the atmosphere with all surfaces of the charge. With its cylindrical shape the chamber accommodates a large volume of work within a small wall area and operates at greater efficiency than the firm's equivalent horizontal rectangular furnace. Atmosphere consumption is reduced due to the smaller volume of heating chamber to be purged.

The work, normally in a nickel-chrome basket, is moved into the furnace through an outer, vertical rising door to enter a purging vestibule, where it stands on one of the two platforms of a quench elevator. At the outer door a gas curtain automatically prevents ingress of air when the door is open. Both the door and the quench elevator are pneumatically operated. After purging, the charge is transferred to the furnace bung, where it is supported on suitable stools which allow free circulation of the atmosphere.

A rail-mounted charge trolley is used to move the charge horizontally from the outer loading table into the purging vestibule and to and from the furnace bung. There is built into the trolley a raising and lowering mechanism, which is operated from outside the furnace with a removable push rod. The trolley can be moved in and out of the furnace without raising the outer door, a swinging counterbalanced flap attached to the outer door being provided for this purpose. After a charging operation, the trolley is lowered and withdrawn.

Stops are provided to ensure accurate location of the charge on the quench elevator and on the furnace bung, which is raised hydraulically to lift and seal the charge into the heating chamber. The charge is removed from the chamber by lowering the bung and transferring it to the quench elevator by the charge trolley. When the charge has been lowered into the integral quench tank, the outer furnace door can be raised and a new charge inserted.

The purging vestibule and the space beneath the heating chamber are water cooled. The quench tank is fitted with oil preheaters, a multi-tube water-cooling system, and a two-speed reversible agitator and baffle arrangement to direct a large volume of oil over the charge being quenched. This agitator, its driving motor and the cooling system are mounted on a removable top plate for easy access for maintenance. If required, the furnace can also be supplied with a hot oil quench tank for marquenching, this tank being of larger capacity and fitted with special air-cooled tubes. Atmospheres for the carburising and carbonitriding processes are obtained from an "Efco" endothermic generator operating on town's gas or liquid petroleum gas.



Vertical cylindrical closed quench carburising furnace

Welding Equipment Demonstration

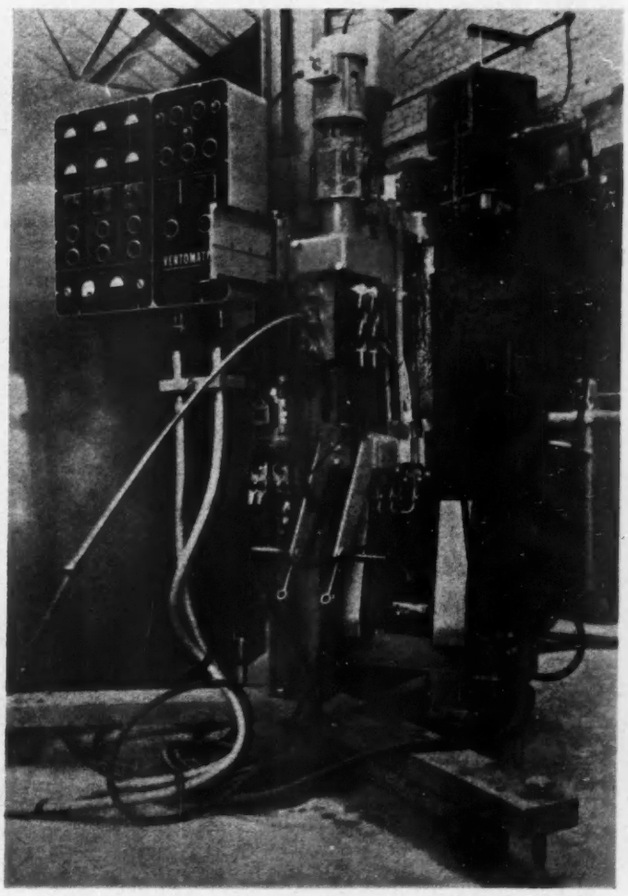
SOME recently introduced welding equipment demonstrated by Rockweld, Ltd., in its factory at Grafton Road, Croydon, Surrey, included the "Vertomatic" automatic vertical slag-welding machine we illustrate below. Rockweld, Ltd., acquired a licence for the manufacture of this machine from Vus (Bratislava), and it is particularly intended for welding heavy plates of 1¼in to 14in thickness. Its welding head is mounted on a carriage which has a vertical traverse up a column to enable plates up to 13ft wide, or more, to be welded together.

The plates to be welded are set vertically in front of the machine carriage with a gap of 1¼in to 1½in between the edges. From the carriage the electrode wire or wires, depending upon the thickness of the plates, are fed downwards through curved guides into the gap between the plates. A prepared block is placed at the bottom of the gap between the plates to close the welding cavity for starting purposes. Water-cooled copper shoes on each side of the cavity move up the faces of the plates as the carriage is elevated to form in effect a mould for the molten weld metal.

Granulated flux is dropped into this prepared cavity and an initiating arc is established with the electrode wire in a manner similar to the submerged arc process. Arc energy, however, is used only initially to fuse the flux into molten slag, which then, owing to its temperature, becomes a highly ionised mass offering a path of relatively low resistance to current flowing from the electrode wire to the pool of weld metal and the adjacent plate edges. Electrical energy expended in the slag and weld metal in this way maintains continuous fusion of the electrode wire. To obtain consistent energy dissipation with thick plates a transverse motion, backwards and forwards, can be automatically imparted to the electrode wire as it is fed into the slag.

During the welding operation contact between the shoes and the parent plates is maintained by pressure exerted from flexibly mounted arms. The automatic movement of the welding nozzle and shoes and the automatic supply of flux are controlled by a set of relays operated by contacts attached to one of the shoes. This method of control maintains a consistent head of molten slag above the pool of weld metal. As the pool of weld metal builds up, the lower part is continuously cooling to form a homogeneous weld with effective penetration of the parent plates and with smooth, clean, external faces contoured by the copper shoes. Penetration is controlled by the width of gap between the parent plates and by voltage applied across the weld. The control equipment provides for the adjustment of the voltage, which can be preset or varied during welding. The transverse movement of the wire feed nozzle is also adjustable and its correct setting plays an important part in ensuring consistent mechanical properties.

The firm also demonstrated its "Comet" semi-automatic welding process with CO_2 shielding, using a special composite continuous wire. This wire is of wrapped steel strip design, with channels which contain the necessary deoxidising agents and slag-forming materials in granular form. The equipment incorporates the firm's "Autopak" transformer and welding head. The head is mounted on a carriage, together with a wire spool coupled through a flexible feed tube to a gun. Carbon dioxide is fed from cylinders to the gun via a pressure regulator and flowmeter, and is introduced round the arc area through an annular copper nozzle on the gun. With the "Autopak" head the wire feed is controlled automatically, as with submerged arc welding, to give a preselected constant arc voltage.



Vertical slag welding machine for plates from 1¼in to 14in thick

Transporter Equipment for Concrete Blocks

A SPECIAL transporter has been designed and built by Robert Hudson, Ltd., of Leeds, for the United Kingdom Atomic Energy Authority Research Establishment, Harwell. The two special transporters, which are to be used on the 7 GeV proton synchrotron project, can be seen in our illustrations. They will be used in the experimental area adjacent to the magnet room for moving and placing in position concrete shielding blocks in packs of five, having a total weight of 125 tons. The equipment consists of an electrically powered traction vehicle coupled to trolleys fitted with hydraulic lifting jacks and running on steel rails. In the interests of safety to personnel the trolleys are fitted with manually operated emergency stop switches and, in addition, automatic switches are fitted to the trolleys and truck to prevent overrunning the limits of longitudinal travel.

The trolley assembly consists of four trolleys arranged to run as two pairs, connected together and to the power unit by drawbars. The traction truck carries all the controls for the hydraulic and electrical gear in addition to the motors and pumps.

Each trolley runs on eight forged steel wheels with roller bearings and is fitted with a hydraulic jack of 62½ tons capacity, or equivalent to double the required working load. Pressure fluid is supplied to the jacks through flexible hoses with self-sealing couplings, designed to enable the traction unit and trolleys to be disconnected without loss of fluid. The single-acting jacks, with self-aligning caps, have a large bearing area to minimise pressure on the concrete blocks. All electric and hydraulic services are duplicated on the trolleys so that it is possible to connect the traction unit to either end of the trolley assembly. The emergency stop switches and limit switches are mounted on a common bracket, which permits their fitting at either end of the trolley assembly.

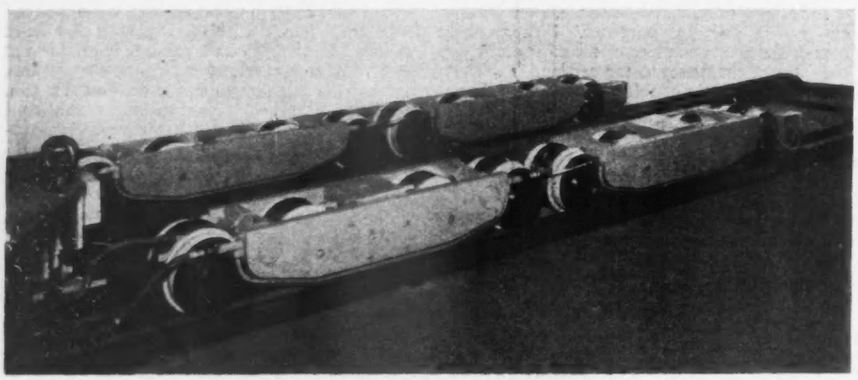
The traction truck is carried on eight wheels mounted on two axles. Both axles, fitted with spherical roller bearings running in cast steel axleboxes, are driven and, to ensure that there is sufficient adhesion, the wheels are fitted with solid rubber tyres. The wheels run on the same rails as the trolley units and the outer wheels have steel flanges. Tractive effort is provided by a 2 h.p. electric motor through a 2000 to 1 double worm reduction gearbox, the final drive and that between the two axles being by duplex roller chain. The drive incorporates a hydraulic coupling, which prevents damage to the gearbox due to overloading and permits smooth "take-up." A magnetic brake is fitted and the longitudinal speed of the unit is about 4ft per minute.

In addition to its longitudinal movement means are provided to move the truck laterally and for this purpose a further set of four wheels is provided. These wheels also are fitted with rubber tyres and when not in use are retracted clear of the floor. They are brought into operation by hydraulic jacks operating downwards on the centre of the axle to raise the whole vehicle clear of the ground, as shown in our second illustration. The drive for these traversing wheels is by a ½ h.p. electric motor through reduction gear units and vee belts, giving a lateral speed of approximately 12ft per minute.

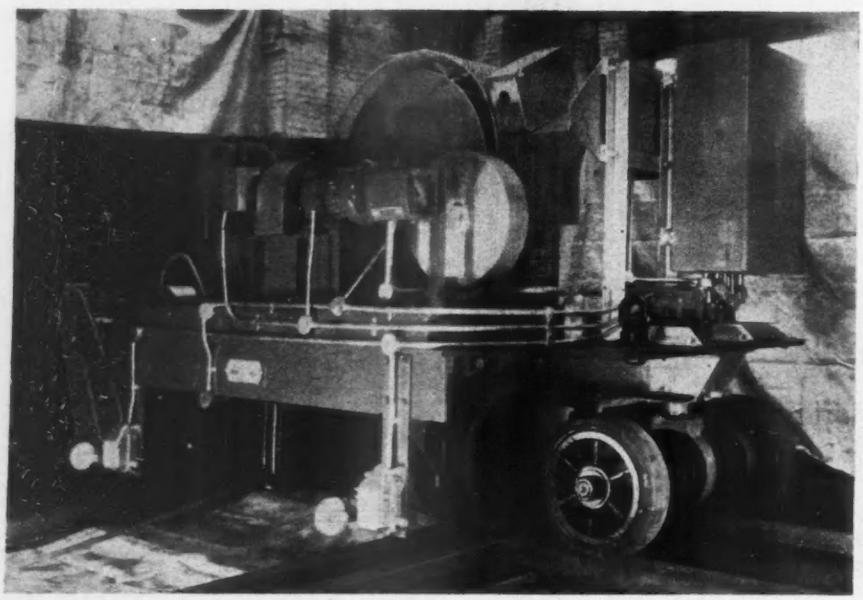
To allow the truck to be turned about its vertical axis a ball bearing turntable is incorporated underneath the frame. This turntable assembly is operated by a hydraulic jack which can raise the complete unit clear of the ground so that it can be turned manually on the turntable as a base. An electric limit switch is incorporated which renders all the transmission motors inoperative when the turntable is lowered.

Power for the various motors is carried by a screened trailing cable which is automatically wound or unwound by a reeling drum fitted on the chassis. The mechanism of the drum includes a pair of hunting tooth limit switches to prevent damage to the cable due to over- or under-winding. As in the case of the trolleys, a pair of limit switches is built on the end of the vehicle to control the extent of longitudinal travel.

The electric transmission motors are operated by push-button controls and the hydraulic jacks by lever-operated valves, all controls being fitted into a panel on the traction truck. By a special arrangement of the hydraulic controls the four jacks on the trolleys, used for lifting the load, can be operated individually or in pairs. This is effected by throwing a lever which couples or uncouples the valve-operating spindles and ensures that the blocks are lifted evenly, or that if any tilt develops it can be corrected at once.



Trolleys for transporting and placing concrete blocks



Driving equipment side of traction truck designed for longitudinal and transverse movements

Tyne Tunnel

THE Minister of Transport and Civil Aviation has approved proposals for the construction of a vehicular tunnel between Jarrow and Howdon under the River Tyne. The tunnel was previously authorised by Parliament in the Tyne Tunnel Acts of 1946 and 1956 (and was described in THE ENGINEER of June 13, 1947), and has been under consideration since 1938. As a result of further consideration being given to the scheme, new plans have been prepared by Messrs. Mott, Hay and Anderson, the consulting engineers for the project, which will enable the tunnel to be driven through bed-rock underneath the river, and will provide accommodation in the approaches for the toll booths. The two County Councils concerned have therefore decided to promote a bill in the 1959–60 session of Parliament to authorise the new plans, the financial arrangements agreed between the Minister and the Councils, and the collection of tolls.

If Parliament passes this Bill it is expected that the work of construction will start towards the end of 1960 and that the tunnel and its approaches will be completed in some five or six years. The project is estimated to cost about £12,500,000.

Trunk Dialling from Call Boxes

NEW "pay-on-answer" call boxes from which trunk telephone calls may be dialled were inaugurated in Bristol on September 5 when the Lord Mayor of Bristol dialled a call from one of the boxes to the Lord Mayor of London. Charging for calls is on a time basis to conform with the operation of the subscriber trunk dialling system, and the boxes have slots for threepenny pieces, sixpences and shillings. When the connection has been established a signal consisting of a rapid succession of pips is heard as the instruction to insert the coins. The time allowed for a given charge depends on the distance of the call. Before the call is due to end, the pips, known as the "paytone," are heard again by both parties to the conversation, and there are then about nine seconds to spare in which to end the conversation or insert more money. The boxes are designed so that the initial payment cannot be made until the person being called has answered the telephone, and he hears the "paytone" on lifting the receiver before the conversation can begin. Initially, some twenty-three boxes of this type are being tried in the centre of Bristol. The routing and charging equipment used in connection with subscriber trunk dialling was the subject of articles in our issues of January 30 and March 27 this year.

Industrial and Labour Notes

The Ninety-First T.U.C.

At the opening of the ninety-first Trades Union Congress, at Blackpool, on Monday morning, the president, Mr. Robert Willis, said in his address that the shorter working week, longer holidays and " new standards " had taken the place of the normal orthodox demands for mere increases in wages. The first phase of a second industrial revolution was now beginning, he remarked, in which the tendency was towards the devaluation of the human brain in its simple and more routine decisions. Automation and electronics mechanised the thought processes as early machines had mechanised hand operations. Those changing methods, Mr. Willis continued, demanded from industry, and particularly from the trade unions, a re-thinking on industrial relations, a new approach and a new assessment. That, he added, must come from both sides of industry if a solution was to be found. Commenting on demarcation problems, Mr. Willis said the workers knew and the country should be told that demarcation lines were drawn up, not lightly, but to provide protection and security for the workers in the organisations concerned. The possibility of demarcation disputes would be lessened only if that protection and security could be guaranteed by other means.

A resolution submitted on Monday afternoon by the Engineer Surveyors' Association, urged the general council of the T.U.C. " to instruct all affiliated unions to examine their structure and to define clearly the function of their officers and shop stewards." The proposer of this resolution said it was time for the unions to assert their position when the authority of national leaders was flouted by shop stewards and dissident groups of members. It was no act of statesmanship by a union to make constitutional any unwarranted action which a shop steward might take it upon himself to decide. The resolution was rejected on the advice of the general council. Sir Thomas Williamson, who spoke for the general council, pointed out that the council had no power to instruct unions. He went on to say, however, that the fact must be faced that there had recently been a number of serious unofficial stoppages of work which had created serious concern both inside and outside the trade union movement. Many of these disputes, Sir Thomas continued, were on comparatively trivial issues which could have been settled satisfactorily if the machinery and procedure arrangements had been followed. The stoppages, Sir Thomas remarked, had been called by shop stewards in complete violation of the working agreements and in some cases before the executives of the unions knew that disputes existed. The trade unions, Sir Thomas emphasised, stood together as a movement for the honouring of agreements to which they put their signatures ; it would be a sorry day when they departed from that principle. Sir Thomas said he was authorised to give an undertaking on behalf of the general council that it would take steps immediately to examine the whole situation on a broader basis than that contained in the resolution. The general council would report to congress in due course.

Maintaining Full Employment

In the latest issue of *District Bank Review*, there appears an article by Professor A. N. Shimmin entitled " Money, Trade and Employment." He points out that when gentle inflation acquires added vigour, it threatens the currency, the balance of trade and the whole range of employment. Yet, Professor Shimmin asserts, the faith of the community in gentle inflation as the guarantee of full employment is undiminished. When, on the other hand, deflation is invoked it is condemned as the cause of unemployment and reduced incomes. Then, Professor Shimmin adds, the Cohen committee's appeal for stability in prices and incomes, endorsed as it is by the Chancellor of the Exchequer, is countered by claims for more pay. Whilst, therefore, the aim of preserving full employment is generally accepted, the capacity of existing administrative techniques to execute such a policy in adverse conditions has not been conclusively tested in practice.

Both the Cohen and the Radcliffe committees, the article continues, have recognised that monetary measures alone cannot keep the national economy in the balance and Professor Shimmin's submission is that the doctrine of consumer credit assumes that the productive system is much more flexible than is the case. The last hundred years, the article suggests, have produced a structure that is very rigid and an urge to monopoly has brought an array of restrictive practices among employers and workers alike. High prices and high incomes have not solved the problem of the redundant craftsman who is confronted with the keenly defended specialisms in other areas of employment. Full employment, Professor Shimmin emphasises, is not simply the retraining or re-absorption of 1, 2 or 3 per cent of the industrial population. It is the task of ensuring that the skilled man shall be fully and continuously employed and the trade unions are obviously concerned about the diminished security of the skilled man. Professor Shimmin puts forward the view that this central question cannot be dealt with merely by the control of cash and credit. Automation, he says, will displace many of the specialisations that have made the structure of industry so inflexible. But now that greater flexibility is being demanded in monetary techniques there is a good opportunity to make employment more continuous by reviewing the pattern created by the subdivision of labour. The secret of full employment, according to Professor Shimmin, may be found eventually in the fashioning of a new basis for the contract of employment.

Safety in Industry

A method by which a fuller appreciation of the importance of industrial safety has been achieved is reported by the National Institute of Industrial Psychology. The management of a South of England factory, employing about 550 people, although not dissatisfied about the accident rate, took the view that there was always room for improvement. In consequence, it asked the Institute to conduct an " attitude survey " among the employees on the question of safety. The Institute sent along skilled investigators who invited the workers to say what they thought was good and bad in the factory and how what was wrong might be remedied. The answers were collated and analysed and recommendations were made to the management.

The Institute says that, at this particular factory, the workpeople were critical of some aspects of the safety rules and campaigns. They were sceptical about the company's slogan that " safety came before production," commenting that if that was really so there would not be incentive bonus schemes which encouraged hasty and careless actions ! Other comments were that the full-time safety officer did not appear to have enough authority to deal with the needs and problems of particular departments and that there was a dislike of " safety competitions " in which employees' days off through injury counted against the record of a department or group. Many of the workpeople seemed to think that safety competitions were wrong in principle and were not fair to all the participants because people in different departments were exposed to different hazards. The investigation revealed also that notices and bulletins and managers' monthly meetings on safety were making less impact than was desirable.

The Institute claims that, as a result of the survey and a careful study of the report resulting from it, the firm has made many improvements in its safety organisation. It has introduced regular meetings of managements of associated departments, provided training in public speaking for managers, rationalised safety rules and brought them up to date in consultation with the workpeople, strengthened induction training on safety, made arrangements for the prompter removal of possible hazards and altered its approach to the question of encouraging safety practices. Much wasted effort has been spared, it is stated, and both workers and management have derived considerable satisfaction from the survey and from the action taken as a result of it.

The Economic Outlook

In a statement issued with the annual report of the George Cohen 600 Group, Ltd., the chairman, Mr. Cyril M. Cohen, says that, as the national economy is so finely balanced, this country cannot afford to jeopardise both its competitive strength in world markets and its opportunities for full recovery. Any further wage increases or shorter standard hours of working, unaccompanied by compensating increases in production, would inevitably undermine the nation's hard-won prosperity. Mr. Cohen goes on to remark that industrial relations based on mutual trust and understanding between employers and employees, stability of prices, the right of private enterprise to get on with its job unfettered by a multitude of controls and unequivocal freedom from threats of nationalisation, are fundamental to the continued growth of prosperity and the economic well-being of the country as a whole.

Telescopic Caisson Lighthouse

For some years now it has been the practice in Sweden to build offshore lighthouses on concrete caissons which are prefabricated in port and floated into position. In order to reduce to a minimum the proportion of the work which has to be carried out at sea, a method has been devised by which a complete lighthouse is built in the form of a double telescopic caisson. This is launched, towed to its site, and erected by first sinking the outer caisson on a prepared bed, then raising the inner caisson—the tower—by pumping water into the space between the two caissons.

THE complex shape of the Swedish coastline, with its multitude of islands, shoals and reefs, requires a considerable number of daymarks, buoys and beacons to mark approaches and channels. While buoys and lightships frequently represent the best or only means of marking, they have often to be taken into port because of ice conditions. It has therefore been the policy of the authorities for many years to replace buoys and light vessels by fixed beacons standing on the seabed. These can operate all the year round, and are cheaper to run and maintain than lightships. Frequently, several such lighthouses belonging to a group can be operated from a common centre. Even the difficult problem of gaining access to lighthouses in the winter, during severe icing, has now been solved by providing helicopter landing platforms at the top of the lighthouse towers.

The first lighthouse built off the shore was the Dämman lighthouse, in the Kalmar Sound, erected in place of the previously authorised lightship, and put into service in 1874. In the present century, and especially since the second world war, many lightships have been taken out of commission and replaced by lighthouses. By using novel techniques, the cost of lighthouses and the construction time required have been substantially lowered. This is of great importance not only because of the savings on first cost, but because the lightship which is to be replaced by a beacon can be withdrawn sooner.

Because of the frequently large distances of the sites from land and from the nearest harbour, and the interruptions and dangers from storms, time is at a premium in all such work. The fundamental principle is therefore " to build on land "—that is to say, prefabricate as much as possible. The most advanced methods allow not only almost the whole structure to be prefabricated, but also a major proportion of the final installation to be put in on land. It is obviously a great saving to use highly skilled men in port rather than at an open site where they may have to stand by for weeks in order to wait for suitable conditions. In fact, of the ten men or so who are needed at the construction site, the majority are unskilled workers.

To Mr. R. Gellerstad, Engineer-in-Charge of the Lighthouse Section of the Building Department of the Swedish Board of Pilotage, Lighthouses and Buoys (Kungl. Sjöfartsstyrelsen) and his team must go the credit for devising and developing these techniques which will now be reviewed.

In Swedish waters the reefs and shoals on which lighthouse foundations are based are most commonly hard granite rocks, sometimes moraines from the Glacial Period ; less frequently sand and hard clay are encountered.

In the case of the Hällgrund lighthouse, completed in 1953, which is founded on a submarine rock, the procedure was to prepare by blasting a level surface free from fissures. On this was bedded the foundation caisson which had been built on land and floated into position. Work began in March, 1951, with the construction in Stockholm of a caisson of 8m diameter and 4·5m height. This caisson was provided with a temporary timber bottom, and after launching by crane—it weighed 59 tons—it was towed 165 miles to the site off Söderhamm. There it was sunk on to three concrete plinths cast on the prepared bed at a depth of 4m, and attached to anchor bars grouted into boreholes. These holes had been drilled from a platform standing on the seabed on adjustable legs. After removal of the timber bottom, low walls of sandbags were built inside and outside along the periphery. By filling the gap with concrete, the caisson was cast on to the rock. It could then be pumped out and the remaining work could be carried out in the dry state.

The question of securely anchoring the lighthouse is of great importance. Attention must be paid not only to wave and wind forces, but also to the very heavy ice pressures which can occur. Depending on whether the projected site does or does not obtain a measure of shelter from outlying islands or rocks, the lighthouses are built to withstand 50 to 150 tons per metre applied

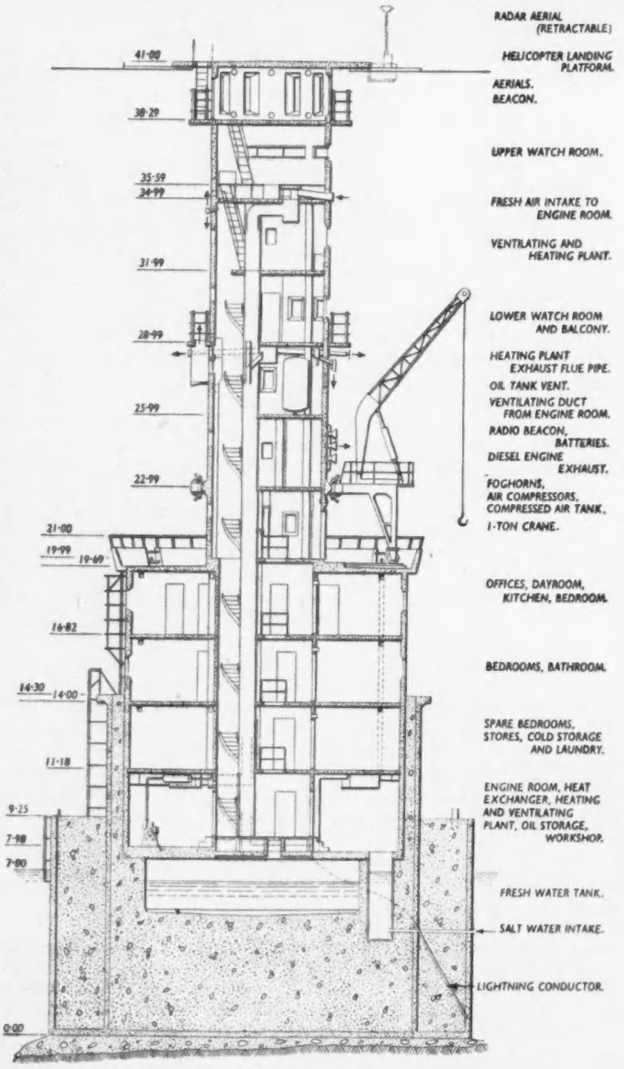


Fig. 1—Sectional elevation of Grundkallen lighthouse. The drawing shows clearly the double outer caisson (two concrete shells to 9·25m and 14m level on a flat circular base), and the inner caisson of which only the six lower storeys are prefabricated. After siting the caissons, the inner caisson is raised by 7·5m by pumping water into the intermediate space, and the two sections are cast together. The five upper storeys of the tower are then completed

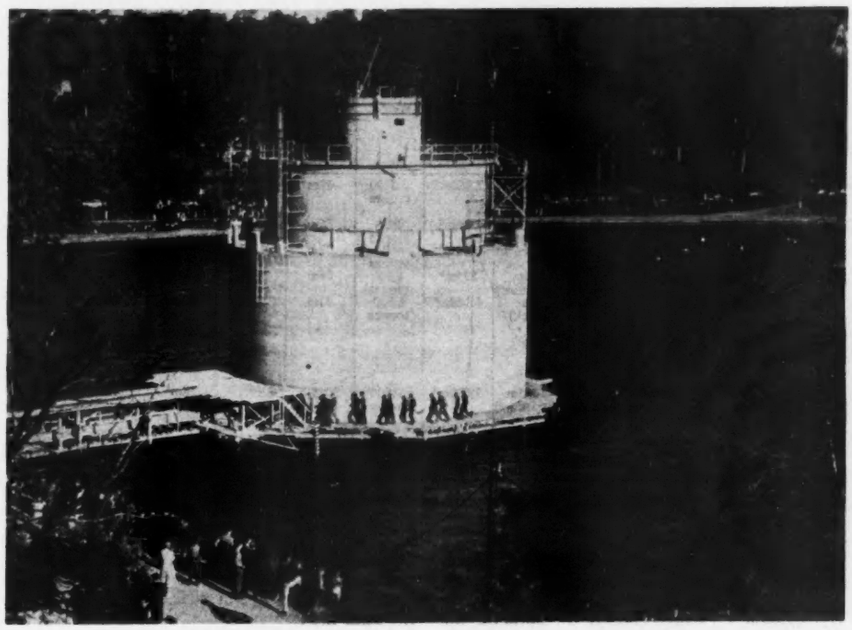


Fig. 2—The double-walled outer caisson and the top of the inner caisson of Grundkallen lighthouse during construction on a collapsible piled launching platform

0·5m above the mean water level. It is usual to assume wind forces on the towers of 150 kg to 250 kg per square metre. The larger structures, and especially the manned lighthouses, must also be capable of withstanding collisions with ships.

The foundation was completed by fixing the remaining anchorage bars and, after installation

Fig. 3—Grundkallen, the first lighthouse constructed according to the telescopic principle

of shuttering for a central well for engine cooling water and its connecting tubes to the outside, filling the space with crushed stone. A 10cm thick concrete slab was cast over the stone, and the interstices of the filling were grouted by cement injections according to the "Prepact" method. For that purpose, eight slotted 1½in pipes had been placed in the stone filling into which flexible hoses could be inserted for pumping in cement, these hoses being pulled up as the cement level rose.

Subsequently, the concrete tower was completed by traditional methods. Including interruptions by bad weather and the making good of storm damage, thirty-nine weeks were required on site. This lighthouse is equipped with acetylene and electric beacons, fog signal, diesel power plant, and equipment for control from a pilot station 3·5 miles away. It has an enclosed volume of 546 cubic metres and a concrete volume of 355 cubic metres and is designed to resist 150 tonnes per metre of ice pressure at 0·5m above the mean water level and wind forces of 250 kg per square metre.

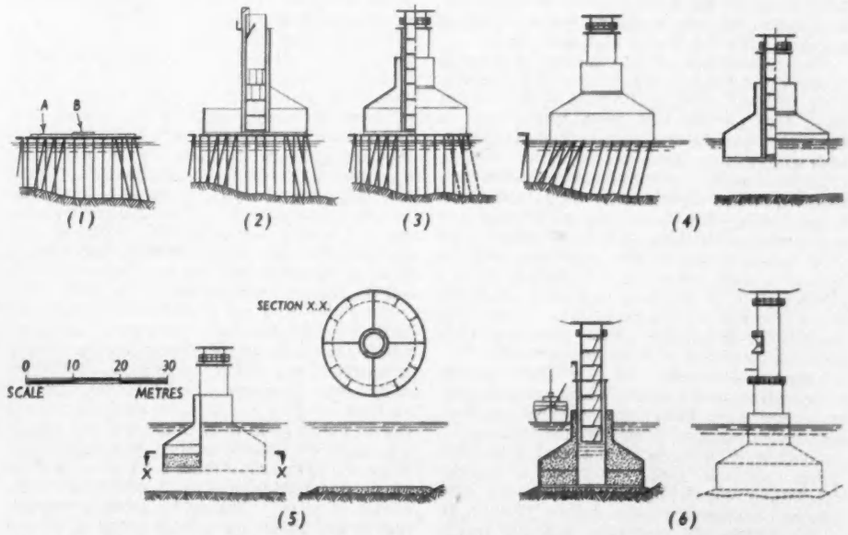
Several other lighthouses and unmanned beacons have been built successfully on the same principle. In the case of Engelska Grundet lighthouse, replacing the "Grepen" light vessel (in the Oregrundsgrepen, 35m E.S.E. Gävle, 1954–55), the caisson of 6·3m diameter and 5·5m height was precast with the use of sliding shuttering above the level of the timber bottom. Above the conventionally timber-shuttered base floor, slide forms were used for the tower.

An interesting construction was carried out in March, 1956, and may be mentioned in passing. When the Storbränningen lighthouse, off the entrance to Umeå (in the Gulf of Bothnia, 63 deg. 38 min N., 20 deg. 22 min E.), was built, workmen and material, including prefabricated concrete units and ready-mixed concrete, were brought over the ice by lorry. On account of the height of the structure, a 12-ton fork lift truck had to be used in the work which was completed within seven days.

A further step in the development of the caisson method was taken in 1957 with the lighthouse Argos Grund (60 deg. 38 min N., 18 deg. 22 min E.) in the South Bothnian Gulf. It had been found that the temporary wooden bottom of the caisson was expensive to install and time-consuming to remove, in particular as the internal rim against which it rested precluded the use of sliding forms to this level. Moreover, its removal at the site wasted valuable time. The Argos Grund caisson was therefore built with an airtight concrete top, the bottom after launching being open to the sea. By admitting compressed air the bell-shaped caisson could be floated at whichever draught was permissible, or sunk temporarily to the bottom if a storm sprang up during the towing. Its inherent stability had been established by model tests; if overcharged with air, it would tilt until some of the air could escape at the side, and then settle back.

The good manœuvrability of this caisson obviated the need for careful levelling of the seabed, as it was easy to set it up on level supports prior to concreting to the base. Prefabricated concrete parts were used for the lower part of the tower, and sliding shuttering for the higher sections. This lighthouse is designed to withstand 150 tons per metre of ice pressure at 0·5m above sea level, and is fastened to the rock with prestressed iron straps. Twenty-two weeks was the total time required for work at the site which is 6 nautical miles from the nearest island and 12 nautical miles from the nearest mainland shore, and the cost, including equipment, was 146,000 kronor.

With Grundkallen Lighthouse (Figs. 1 and 2) which was begun last year and has now been commissioned, we enter on the most recent design phase. The caisson principle is extended yet a step further: if it was possible to build the foundation caisson on land, launch it and tow it to the site, why not the whole lighthouse? To do so would reduce still more the expensive



1—Piled base on which are cast successively the bottom slabs of the outer and inner caissons *A* and *B*.
2—The tower and its surrounding shaft are cast, using sliding shuttering.
3—Completion of outer caisson outer wall) by using sliding shuttering. Completion of formwork inside tower and of top with helicopter platform. Installation of plant and equipment. Removal of piles shown dotted prior to launching.
4—Launching—at this stage the weight of the caisson set is 1650 tonnes.
5—Partial filling with graded stones as ballast, and towing to site.
6—Sinking on levelled site. Completion of filling (gravel at Nordvalen; gravel or sand at Svinbådan). Injection of stone filling with cement mortar.
Raising of telescopic tower by 15m by flooding the central caisson shaft, together with the use of jacks.
The tower and shaft are cast together. After connecting the power and control cable the lighthouse is ready for service.

Fig. 4—Stages of construction of Nordvalen lighthouse

TABLE I—*Some Recent Swedish Lighthouses*

Name of lighthouse	Method of construction	Beginning of work	Date of sinking of caisson	Date of commissioning	Site	Caissons					Whole of lighthouse			Construction of walls and floors			
						Largest diameter	Height	Enclosed volume	Weight	Depth and nature of seabed and foundation	Enclosed volume	Weight	Overall height from seabed	On land	At sea	Total	Percentage of construction carried out at sea
Olands Södra-grund	—	Spring, 1947	May 12, 1949	September, 1951	S.E. off Oland	20m	—	6,300m³	3,000 tonnes	12m (moraine)	7,860m³	11,000 tonnes	47m	3,950m³	2,540m³	6,490m³	39 per cent
Hällgrund	Caisson	March, 1951	July 14, 1951	September, 1952	Off Söderhamn	8m	4m	225m³	59 tonnes	3·5m (4m rock)	546m³	820 tonnes	26m	—	—	—	—
Kungsgrundet	Caisson	1955	July 7, 1955	October, 1956	—	7·3m	—	255m³	60 tonnes	4m (rock)	635m³	875 tonnes	32m	—	—	—	—
Nygrån	Caisson	March, 1957	August 14, 1957	August, 1958	—	14m	—	398m³	350 tonnes	5·5m (moraine)	535m³	1,100 tonnes	26m	—	—	—	—
Grundkallen	Telescopic caissons	November, 1957	July 12, 1958	August, 1959	South Bothnian Sea, 60 deg. 30 min N., 18 deg. 51 min E.	18·2m	14m	3,150m³	1,650 tonnes	7m (rock)	4,160m³	6,300 tonnes	41m	2,870m³	470m³	3,340m³	14 per cent
Nordvalen	Telescopic caissons	January, 1959	July 28, 1959*	1959†	East of Umeå (Ostra Kvarken)	22m	—	3,400m³	1,650 tonnes‡	13·5m (moraine)	3,600m³	7,500 tonnes	39·5m	2,102m³	16m³	2,118m³	<1 per cent
Svinbådan	Telescopic caissons	January, 1959	1959†	1959†	Oresund	22m	—	3,400m³	1,650 tonnes‡	14m (sand and hard clay)	3,600m³	7,500 tonnes	39·5m	2,102m³	16m³	2,118m³	<1 per cent

* Date of launching. † Probable date. ‡ Fully equipped with machinery, but excluding ballast.

and dangerous work at sea. On the other hand, a complete lighthouse would be too top-heavy to be stable in the water at a reasonably shallow draught.

The upshot of these considerations was the device known as the "telescopic caisson." Two closed-bottom sections are built one nesting inside the other. After bedding down the outer foundation caisson, the inner tower caisson is raised by pumping in water, and fixed in position by casting it on to the outer caisson.

The lighthouse at 60 deg. 30 min N., 18 deg. 51 min E. in the South Bothnian Sea replaces the light-vessel "Grundkallen" (60 deg. 34 min N., 18 deg. 58 min E.). It is founded on a shoal approximately 8 nautical miles off the nearest islands which are to the south-west and west. The distances to the nearest berth and the mainland are, respectively, 14 and 33 nautical miles.

The caisson set consists of two caissons of which the outer or supporting caisson has an outer diameter of 18·2m and a height of 14m. Internally, it has a 13m diameter circular shaft, with six buoyancy pockets in the intermediate space. Inside this shaft was built the tower caisson containing the engine-room and the crew's living quarters. This has a diameter of 12m and a height of 12·2m, and comprises four floors, with a central circular stair well. Round the staircase on each floor are grouped six rooms each of 12 square metres. The two bottom floors are mainly used for machinery and stores, and the next two floors for living quarters, while the beacon itself is above.

The construction of the caissons at a small harbour near Stockholm was begun in November, 1957, with the building of a base of 165 wooden piles, 10m to 19m long, which were driven in the water near the quayside. In January, 1958, with temperatures sometimes falling to −10 deg. Cent., the base slab of the outer caisson was cast, followed twelve days later by the inner caisson bottom slab. On these slabs all circular and radial walls, totalling 196m in length and 2000 square metres in area, were cast with the help of sliding shuttering. A quantity of 413 cubic metres of concrete was used, requiring about 50km of reinforcement bars. Some 1000 recesses for subsequent joints, pipes and electrical wiring had to be left in the concrete.

Equipment installed in port included the power plant (three diesel-electric sets), heating and ventilating plant with oil-fired burners, heat exchangers and pumps for the engine cooling circuits, oil tanks holding a total of 50 cubic metres, salt and fresh water tanks, sanitary installations, electric lighting and cooking facilities, and a temporary radio station. The height of the caisson set was 18m, and the weight approximately 1650 tonnes of which the inner caisson accounted for about 800 tonnes.

After test-running the installation, the caisson set was launched. This was done by blasting away the outer inclined piles on the seaward side, and applying a horizontal force of 140 tons by means of a jack; the pile base was collapsed and the caissons set afloat ready to be towed 100 nautical miles to the lighthouse site. There, the bottom of the shoal, consisting of rock, by blasting had been levelled at a depth of 7m. The caisson set was beached by flooding the compartments in the outer caisson; subsequently these were filled with graded stone. By pumping in water between the caissons, the inner one was raised at the rate of 1·5m per hour by 7·3m so as to raise the top to 18m above the water line.

During the whole of this period, the caissons behaved in a very satisfactory manner. Even before the outer caisson had been properly ballasted for towing by half filling it with stone, a tempest of 20m per second was experienced, which was readily withstood as was a wind velocity of 10m per second during the lifting stage.

After raising the inner caisson, the two caissons were cast together. A concrete fresh water tank was installed underneath, together with water and sewage pipes. The remaining space was filled with graded stone. All the fillings were injected with "Prepact" cement, injection of the inner filling being left until this spring, by which time the tower had been carried to its full height of 34m above the water. Our illustration (Fig. 3) shows the lighthouse at this stage. Finally the internal installations and equipment were completed.

It is estimated that the inclusive cost of this lighthouse will not exceed 2,000,000 kronor, which is about 25 per cent less than a similar structure built by the earlier methods.

Perhaps the most important among several advantages claimed for the telescopic method is that building near the water surface is completely avoided. This formerly constituted the most expensive and risky part of the work. No heavy plant is required at sea, and a large part of the machinery intended for the lighthouse itself such as power plant, compressors, pumps, and fans, can be installed on land and used in the construction. The telescopic parts can be readily adjusted both vertically and horizontally. Any structural work that remains is of a minor nature and can be carried out independently of weather conditions.

Since the work on Grundkallen began, two further lighthouses have been taken in hand, which are based on the same principle of construction. Both of them were begun in January of this year. The Nordvalen lighthouse, launched at Piteå on July 28, is to be sited on a shoal east of Umeå (Gulf of Bothnia) and will replace the lightship "Ostra Kvarken" and three buoys. A tow of 120 nautical miles is required to reach the projected site which consists of moraine under 13·5m of water. It may be noted in passing that at this lighthouse a novel design of beacon will be used for the first time, comprising arrays of small searchlights on slewing frames projecting light through slits in the tower, in place of the normal design with rotating lens.

The Svinbådan lighthouse is under construction at Lysekil, on the west coast, and will be launched during August or September, after which it will be towed 140 miles to the northern Oresund off a point between Viken and Höganäs, and beached in 14m of water on a bed of sand and hard clay. It will replace the lightship of the same name.

In their design, these two lighthouses are identical. Our title illustration shows the Nordvalen lighthouse under construction, while Fig. 4 gives a more detailed impression of the design and the procedure of building, launching, siting and erecting.

The outer caisson diameter is 22m and the thickness of the bottom slab 0·7m. On top of this slab was cast the base of the telescopic tower which has a diameter of 4·6m. The tower, and the shaft surrounding it, were then carried to a height of 24·5m and 22m respectively, using sliding shuttering. While the outer wall of the outer caisson which is 0·3m thick was built up—also with the help of sliding shuttering—the internal walls and floors, and the top of the tower with the helicopter platform, were cast in concrete as ordinary formwork. The concrete quantities are listed in the following table.

TABLE II—*Nordvalen/Svinbådan Telescopic Caisson Lighthouse*

Quantities of concrete

	Cubic metres
Base slab of outer caisson	266
Base slab of inner caisson (tower)	8
Main tower section and shaft	125
Internal concrete work, top section of tower, and helicopter platform	30
Outer wall of outer caisson	100
Radial walls of outer caisson	40
Conical top and cylindrical neck of outer caisson	100

The weight of the Nordvalen lighthouse at the launch amounted to 1650 tonnes, which included all plant and machinery but excluded the ballast. The enclosed volume of the structure is 3400 cubic metres. Altogether, the height of the completed tower is 25m, so that when the lighthouse has been raised at the site, its overall height will be 40m, of which 26m will be above the water line.

Erection will be carried out by pumping water into the central shaft of the outer caisson, jacks being used to assist in this operation and to control the movement. Afterwards, the tower and the shaft will be cast together. Meanwhile, the outer caisson will be completely filled with shingle (or possibly sand, in the case of Svinbådan), the filling being subsequently injected with cement mortar. After connecting the power and control cable, the lighthouse will be ready for operation.

The principal data of some recent Swedish lighthouses, including those described in this article, have been assembled in Table I. Particularly striking is the saving of working time at sea which the telescopic method has made possible. For Grundkallen, off-shore work required only 14 per cent of the total construction time and this percentage is expected to be further reduced in the case of subsequent lighthouses built to the same design. The very low figure of under 1 per cent for the Nordvalen-Svinbådan design seems hardly capable of being improved on.

The American Scene

BY OUR AMERICAN EDITOR

The Steel Strike

The most remarkable phenomenon of the current American steel strike is that it can run so long and do so little visible damage to the national economy. In most other countries, on both sides of the Iron Curtain, each fluctuation in steel production is regarded as a crucial barometer of living standards and national prosperity. Few countries could survive a protracted paralysis in the output of this most basic of industrial metals. In the United States a half-million steel workers have been idle since mid-July. Negotiations for a settlement are proceeding at a pace so lackadaisical that an observer might conclude the tie-up involved a half-dozen peanut vendors. Other industries show no signs of dismay, except for those that directly serve the steel mills, such as railways, coal mines and river barges. The White House stands on its position that Government pressure to hasten a return to work would undermine "free collective bargaining." The striking union and the steel producers appear far removed from a showdown based on the weight of economic hardship. David J. McDonald, the president of the United Steelworkers of America, has assured his members that they will never be starved back to work. The parent union's treasury of 33,000,000 dollars remains virtually untapped. Its local branches have almost as much more available to aid needy strikers. These sums, substantial as they are, represent no realistic measure of the union's ability to withstand an economic siege. The rest of organised labour has embraced the steel strike as the fight of all labour. This is something more than the formal pledge of full support customarily given to any major strike. This time most other unions are convinced that a setback for the steel workers would give management the upper hand in all major collective bargaining. On this basis, the merged labour federation is considering committing itself to raise 25,000,000 dollars to support the steel workers. The commitment will come up for action at a special mobilisation in connection with the A.F.L.-C.I.O. convention in San Francisco on September 18. The date itself is a gloomy indicator of labour's pessimism about how soon the strike will end. The steel union has another financial backer in its contest with the steel companies. When its members reach the end of their personal resources they are advised to turn to public relief agencies for help. The applications lists already are beginning to grow in such principal steel centres as Pittsburgh, Chicago, Youngstown, Canton and Johnstown. So far, the union is getting almost no complaints from strikers or their wives about the tribulations of payless paydays. Mr. McDonald's own mail is heavily weighted with calls to hold out, despite the publication by the industry of hundreds of newspaper advertisements urging union members and citizens generally to tell the union that they oppose its stand. On the company side economic pressure seems almost totally absent. Manufacturers of automobiles, electrical appliances, farm equipment and other key products still report they have enough steel to keep their factories operating until mid-October or later. A Federal survey, just completed, shows few lay-offs yet in smaller works or in the construction industry. Stock shortages of specialty steels will cause some idleness in the second half of September, but mass unemployment in manufacturing industries still seems six weeks or two months away. The commercial warehouses on which most small businesses depend have more steel now than they had at the beginning of the five-week steel strike in 1956. At present consumption rates their reserves would last fourteen more weeks. This means that the impact of the tie-up is restricted to the steel companies and to railways, mining and other tributary industries. The unemployed in these related fields already exceed 125,000. But the steel producers can take comfort in the knowledge that their customers are still living on their prestrike inventories and that these will have to be exhausted before they need fresh supplies. This knowledge, together with tax factors that cut down the companies' out-of-pocket losses during the tie-up, tend to take much of the urgency out of the quest for a peace formula. This absence of compelling financial spurs to a settlement heightens the probability that the mills will not reopen until Present Eisenhower moves for a national emergency injunction under the Taft-Hartley Act. He has made it clear that he will be in no hurry to use this back-to-work instrument. But his timetable must take cognisance of the lag between issuance of the no-strike order and refilling of the empty pipeline of steel distribution. It will take nearly a month to get the mills back to capacity production and to make volume shipments to steel-hungry industries. With these factors to balance against the comfortable steel reserves still in industry's hands, the President is likely to decide on a date in the neighbourhood of October 1. The only drawback in such a solution is that it would settle nothing. After two and a half months of strike the unionists would be obliged to return for eighty days at their old wages aad working conditions, and when the truce ended they would be free to renew their stoppage.

Since World War II, American production of steel has been halted six times by general strikes. The first five ranged in duration from twelve hours in 1955 to fifty-eight days in 1952, and represented an estimated total loss of 45,800,000 tons of steel and 850 million dollars in wages. The sixth post-war steel strike will be the longest in the strike-ridden industry's history. This time the potential losses involved have caused particular concern, for the strike occurs at a time when the economy has boomed its way out of the worst recession since the war. These are the issues: the industry has maintained that any rise in labour costs would be inflationary—that it cannot raise wages without raising prices. It has called on the union to keep wages at present levels for a year. It has expressed willingness to improve pension and insurance benefits this year and grant a "modest" wage increase next year —if the union agreed to new work rules. It also wants to abolish the cost-of-living escalator clause in the now expired contracts. The union, rejecting a wage freeze, has insisted that in view of current high profits the industry can well afford to grant wage rises without raising prices. It seeks a "package" increase of just over 15 cents an hour and retention of the escalator clause, and contends that the present work rules do not prevent the industry from attaining maximum production. The early talks foundered on the explosive issue of work rules. These affect the mill worker's daily life on the job. They are drawn up in each works by agreement between union and management and cannot be changed without union consent. The industry has charged that the stronger voice won by the union has reduced its authority over such areas as crew assignments and led to "unjustified idle time." On the other hand, the steel workers call the work rules issue "phony," and contend the industry is pressing the matter in an attempt to "eliminate every shred of protection of local working conditions." Changing the rules, they say, would leave supervisors "free to abolish spell time, relief arrangements, lunch periods, wash-up time" and other things.

An authorised history of the United States Steel Corporation published several years ago asserted "the right of free men to form unions of their own choosing for the purpose of collective bargaining." Nothing in the current steel strike, one may presume, has changed that position. The steel companies have rejected the proposals of the United Steelworkers of America, but they have not questioned the right of the steelworkers to combine and to make proposals. Upon looking back over the history of the steel industry since the United States Steel Corporation's organisation in 1901, one can detect democratic progress. The barbarous twelve-hour day has given way to a forty-hour week. Money wages have increased something like eight times since 1901, and it is estimated that to-day real wages in steel will buy more than twice what they bought in 1910. Automation has eliminated, perhaps, 100,000 jobs, but it has made life less arduous for the half-million steelworkers affected by the present strike. The companies have done well, too, as their net earnings indicate. Union statisticians assert that each ton of steel produced to-day requires 10·7 man-hours as contrasted with 19·1 man-hours in 1945. Certainly the wage element in the cost of steel has gone down. The picture to-day is of an industry whose processes have been greatly refined and which has a larger net income to share among its workers, its executives and its owners. The issue, then, is basically one of power. The handful of desperate men who fired on the strike-breakers at Homestead, Pennsylvania, in 1892, have been replaced by organisations comparable in authority with the great corporations. In this particular instance the evidence is that the steel companies have concluded that the union steelworkers of America have too much power or are asking too much power. The companies are accordingly not so much refusing monetary benefits as they are moving to curtail this power. Here we have, except for possible outbursts of emotion, the working out of democratic process. It is not pleasant, it is not cheap, it may hurt hundreds of thousands of people not directly concerned, but it is one of the ways in which freedom functions. And one may be sure that when it is all over there will be no "dictatorship" on the part of the companies, and no "monopolistic power" on the part of the unions. The pity is that it costs so much to establish these points.

Nuclear-Powered Passenger-Cargo Ship "Savannah"

BY OUR AMERICAN EDITOR

No. II—(*Continued from page* 205, *September* 4)

The world's first nuclear-powered passenger-cargo ship, the N.S. "Savannah," was launched at the Camden yard of the New York Shipbuilding Corporation in New Jersey by Mrs. Dwight D. Eisenhower on July 21. *The* 22,000-*ton vessel was constructed under a joint contract with the U.S. Maritime Administration and Atomic Energy Commission and will be operated under Government contract by the States Marine Lines. The "Savannah" will be capable of carrying sixty passengers and* 9500 *tons of cargo at a speed of* 21 *knots. She will be able to operate for more than three years on the initial* 52,000 *MWD (megawatt-day) fuel loading of her pressurised water reactor. Her trials are scheduled for the spring of next year.*

Containment Vessel

ALL the equipment in the reactor system is housed within a steel containment vessel in the reactor space (Fig. 6). Because of the weight of the reactor vessel and the various components associated with the reactor system, including approximately 2000 tons of lead and concrete shielding, the reactor space has been placed amidships, just forward of the machinery compartment. The containment vessel (Fig. 7) serves to prevent the escape of radioactive particles to the atmosphere in the event of an accident. The vessel is made up of a 35ft diameter cylindrical section, with two hemispherical ends, and has an overall length of 50ft. A 14ft diameter cupola is situated on top of the cylindrical section. The control rod drives, which are mounted on the reactor vessel head, are housed within the cupola. The vessel has been designed to withstand a pressure of 186 lb per square inch gauge. The wall thickness of the containment vessel varies from 2¼in to almost 4in of carbon steel. The 186 lb per square inch gauge pressure would result from the rupture of a primary coolant pipe and the instantaneous release and expansion of the entire contents of the primary system, which is the maximum credible accident to the reactor plant.

A total of eighty-two penetrations for piping, electrical cables, pneumatic lines and access are provided in the containment vessel shell. The largest penetration is the 14ft diameter opening at the top of the cupola. This opening was used for the initial installation of equipment within the containment vessel. In addition, it will be utilised for refuelling the reactor core. Two 24in by 18in manholes in the lower portion of the vessel and two 42in diameter manholes in the upper portion provide access to the containment vessel. Should the ship sink the two lower manholes have been designed to open inwardly under an external head of 100ft of water. This allows flooding and prevents the collapse of the containment vessel in the event of sinking. The bottom half of the vessel rests in a cradle of steel surrounded by a 4ft wall of reinforced concrete which forms the lower portion of the secondary shield. The top half of the containment vessel is encased in a 6in layer of lead, together with a 6in layer of polyethylene, which forms the upper portion of the secondary shield. In addition, both sides of the vessel are protected by a thick collision mat, constructed of alternate layers of steel and redwood. The amount of radiation at the surface of the shield will not exceed five rems per year at normal operation.

Except when entry is required, the vessel will be sealed. If entry is required, it is possible thirty minutes after reactor shutdown when the radiation level within the vessel is below 200 millirem per hour, or less. Entry into the containment vessel will be kept to a minimum since the internal equipment that could be expected to require normal maintenance is installed in duplicate. In addition, certain segments of the reactor system can be isolated and by-passed without affecting plant operation. The containment air-conditioning system continuously circulates and cools off all the air in the containment vessel, maintaining an average ambient temperature of 130 deg. Fah. and a humidity of 72 per cent.

Shielding Design and Construction

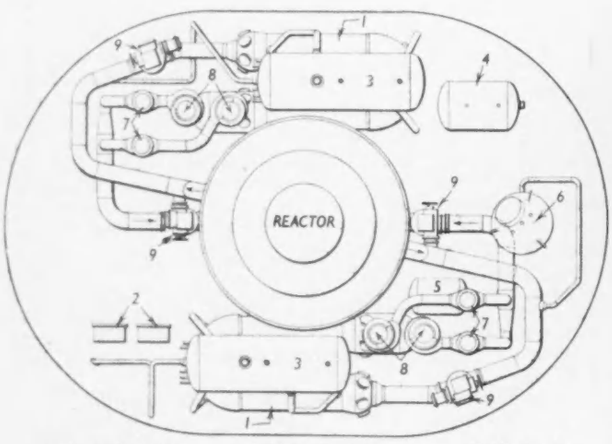
The main sources of radiation during the operation of the power plant are the reactor itself and the primary loop coolant water. This water, which passes through the reactor core, is irradiated in the process and becomes a source of radiation. There are also radiation sources of lesser magnitude, including process piping, hold-up tanks, pumps and demineralisers. By and large, these need not be considered in the design of the main shield, but must be considered during access and maintenance studies. The shield serves the dual purpose of limiting the radiation dose outside the containment to prescribed safe levels and permitting access to the interior of the containment vessel within thirty minutes after shutdown. To accomplish these functions the shield has been divided into a primary shield, which surrounds the reactor itself, and the secondary shield which surrounds the containment vessel.

The primary shield consists of a water-filled tank surrounding the reactor, augmented by an outer lead annulus varying in thickness from 2in to 4in. The tank is 17ft high, with an annular water space of 33in. The lead annulus is bonded to the outer wall of the tank. The primary shield is more than sufficient to limit the dose rate within the containment vessel from core gamma sources and activated nuclei to 200 millirem per hour, a half-hour after the reactor has been shut down. This level will permit limited access of personnel to the containment vessel for maintenance and repair.

The secondary shield consists of lead, polyethylene, concrete and water of sufficient thickness to reduce reactor and coolant doses to allowable levels. The total weight of this secondary shield is approximately 2000 tons. A concrete wall, which encloses the lower part of the containment vessel, comprises the lower portion of the secondary shield. Where available space limited the thickness of the wall, a high density concrete was used instead of ordinary concrete. This wall extends outward from the forward end of the containment vessel to form a compartment between the shield and the containment vessel. This compartment houses the purification demineralisers and components of the waste collection, buffer seal and gaseous waste systems. A series of fresh water shield tanks in the double bottom follow the line of the concrete. These tanks minimise the dose rate outside the shield due to radiation scatter under the concrete. The upper part of the shield is composed of lead slabs (Fig. 8) bolted to the containment vessel. The thickness of the lead varies from 2½in to 6in. The boundaries between slabs are caulked with lead wool rope. The lead support studs are extended to provide attachment for the polyethylene, whose thickness is adjusted to provide a constant shield thickness of 14in. Gaps are provided between adjacent sheets of polyethylene to allow for its high coefficient of expansion.

Reactor System

The reactor is moderated and cooled by light water at 1750 lb per square inch absolute. It is



1—Heat exchanger. 4—Condensing tank. 7—Check valve.
2—Let down coolers. 5—Containment drain tank. 8—Pump.
3—Steam drum. 6—Pressuriser. 9—Gate valve.

Fig. 6—Reactor system arrangement within the containment vessel

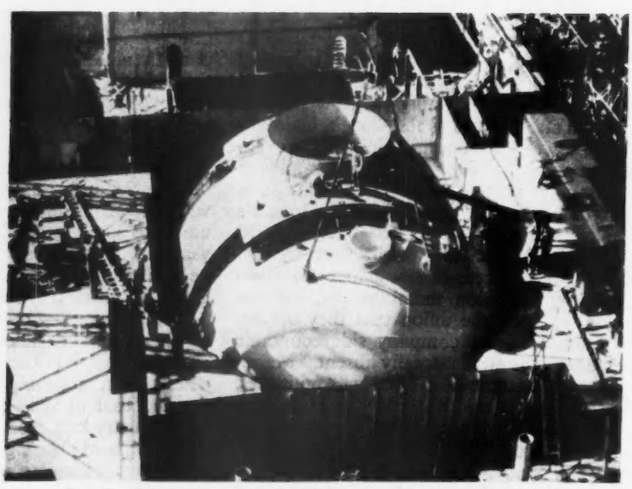


Fig. 7—Site erection of the 50ft long by 35ft diameter reactor containment vessel

Fig. 8—Installation of secondary lead shielding in the reactor containment vessel

fuelled with uranium oxide (UO_2) of about 4·4 per cent enrichment in uranium 235, clad in stainless steel rods. The reactor design was aimed, primarily, at a long core lifetime ; the design target was approximately 52,000 megawatt-days, or 1230 days at the average operating power. to the safety of the system. However, this stability requires that the control system drives the reactor whenever there is a change in the steam load.

A pressurised water reactor system operates on the principle that water under high pressure can be heated to high temperature without boiling in the primary loop. This heat is then transferred to water under much lower pressure, causing it to turn to steam in the secondary loop to operate the turbines and produce power. In steady operation the reactor system will respond automatically to slight variations in steam demand at the turbine throttle by virtue of its negative temperature coefficient. For changes of power demanded from the bridge, automatic control rod operation will cause the reactor to respond without serious lag or deviation in its average coolant temperature. A graphic, colour-coded display of the operation of the a stainless steel "egg crate" lattice. This lattice serves to withstand the pressure differentials that arise as a result of the multi-pass flow pattern. Each fuel element contains 164 rods ½in in diameter. The wall is 0·035in thick stainless steel. The fuel in the rod is uranium oxide pellets, enriched to an average of 4·4 per cent of uranium 235.

The fuel rods in the inner sixteen fuel elements contain uranium oxide (UO_2) at an enrichment of 4·2 per cent U^{235}, and in the outer sixteen fuel elements the enrichment is 4·6 per cent U^{235}. Within each fuel element, the fuel rods are arranged in four bundles of forty-one rods each. The centre-to-centre spacing of the rods is 0·663in, giving an overall metal-to-water ratio of 0·76. The rod spacing is maintained by small tubular stainless steel ferrules brazed in place approximately every 8in along the length of the element. The uranium oxide pellets, 0·4255in in diameter, are made from pressed and sintered UO_2 powder. The space between the pellets and the inner tube wall will contain helium gas under pressure to ensure good heat transfer across the fuel rod. The gas is sealed-in at the time the tube is loaded and the ends plugged.

The initial core loading will include 6788 kg of U^{238} ; the U^{235} content, at the enrichments of 4·2 and 4·6 per cent, will be 312·4 kg. The conversion ratio will be about 0·4 ; i.e. for each gramme of U^{235} that is burned up, 0·4 grammes of Pu^{239} will be produced from the fertile U^{238}. The reactivity requirements as listed below indicate that the cold, clean core

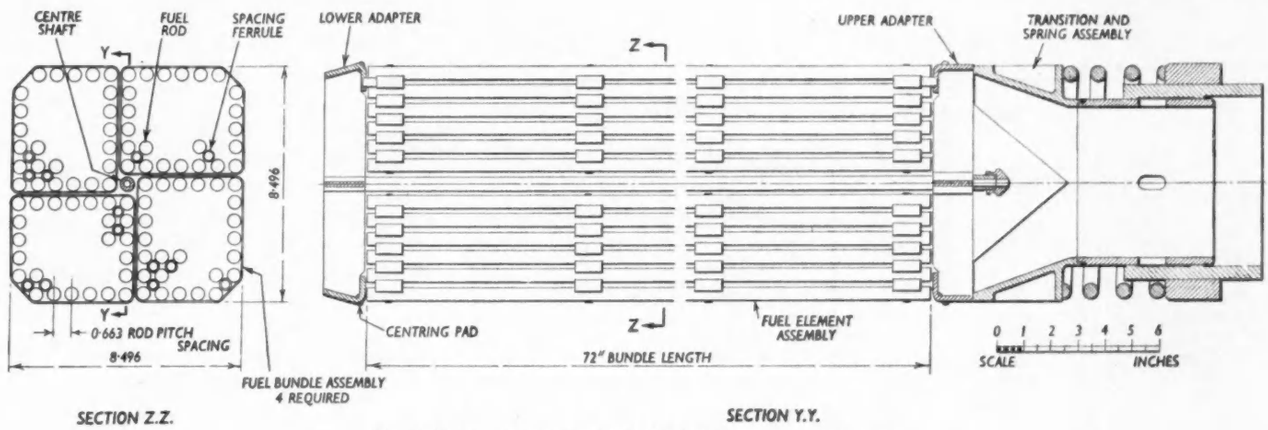


Fig. 9—Design of fuel elements for N.S. "Savannah" reactor core

The active core is approximately a right circular cylinder with an equivalent diameter of 62in and a height of 66in. The core is made up of thirty-two fuel elements, each one consisting of 164 fuel rods. Reactivity control is provided by twenty-one cruciform control rods. Each rod is a composite of a boron-stainless steel plate jacketed with stainless steel plates.

Three basic thermal considerations were followed in the reactor : (1) no bulk boiling is permissible in the core during steady-state operation ; (2) the local heat flux at the outside surface of the cladding will not exceed the design value of burn-out heat flux during steady-state operation ; and (3) melting of the oxide fuel will not happen under the worst possible combination of manufacturing tolerances, neutron flux distribution and fluid flow effects during steady-state or transient operations.

A multi-pass arrangement was selected because it possessed several advantages in thermal performance over a single pass core. There are three passes. The first flow path is upward in the annuli between the vessel and the inner thermal shield ; the second and third passes are through the core. In order to attain the long core lifetime, a large core of low power density is used. The inclusion of uranium 238 as a fertile material extends the core life through its conversion to plutonium. The core is basically stable because of the large negative prompt fuel temperature coefficient. This, backed up by the delayed negative moderator temperature coefficient, adds reactor system will be provided on the main control panel.

Reactor Core and Fuel

Each of the thirty-two fuel elements (Fig. 9) is 8½in square. The elements are confined within

should have an excess reactivity of approximately 11·2 per cent.

	Per cent
Temperature coefficient—68 deg. Fah.—508 deg. Fah. (including power coefficient)	3·2
Xenon and Samarium poisoning	2·0
Power Doppler effect (zero to full power)	1·3
Fuel burn-out and isotope build-up	4·7
Total	11·2

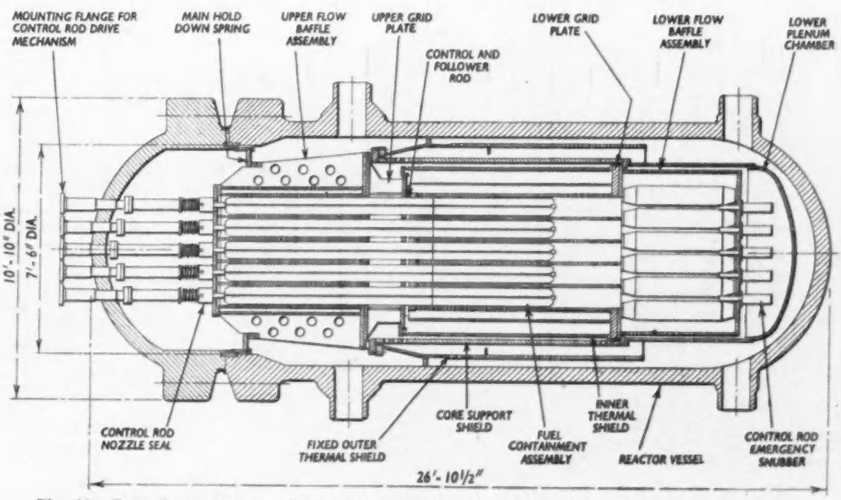


Fig. 10—General arrangement of reactor vessel and fuel containment assembly with control rods

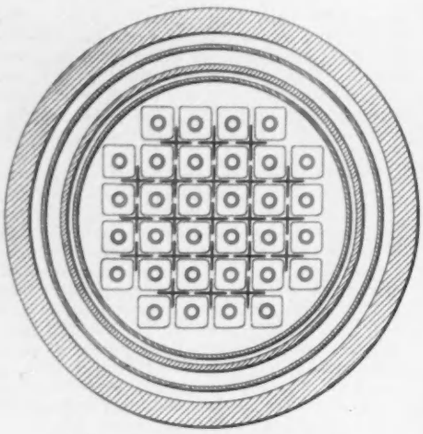


Fig. 11—Cross section of reactor

The control rods will control reactivity in the range of 14 to 18 per cent from cold starting to full power. This value includes an allowance for resonance capture of neutrons by the rods. This data would, therefore, indicate a margin of 2·8 per cent for the cold, clean core.

Many factors are involved in estimating the core life, but all calculations to date conservatively indicate that at normal power, corresponding to 63·5MW of heat, the core should have a life of over 700 normal power operating days. Based on operating 60 per cent of the time at normal power, and 40 per cent at port power, it should not be necessary to reload the core for three and a half years.

The pressure vessel (Figs. 10, 11 and 12) for the reactor is 26ft 6in high and 98in in inside diameter. It is made of 6in carbon steel plate clad on the inside with 18–8 stainless steel. Its design pressure is 2000 lb per square inch and design temperature 650 deg. Fah. The upper head, which carries the control rod drives, may be removed for refuelling. Closure is effected by means of forty-eight 5in studs with a double gasket and a seal weld between the flanges. The closure opening is 90in in diameter—sufficiently large for the removal of all core components which may deteriorate or be damaged during the life of the plant.

Control Rod Mechanism

Each of the twenty-one control rods is in the shape of a cross and is equipped with an electro-mechanical control and a hydraulic cylinder for reactor scram. All drive rods are buffer-sealed where they pass through the reactor head, and each seal is charged with purified water at 1800 lb per square inch pressure. In the event of failure, a seal can be isolated from the system. Each control rod drive assembly can be disconnected from its control rod and removed. Each rod measures 8in across, tip to tip, and is 0·375in thick. The effective length of each rod is 66in. The rod consists of a $\frac{1}{16}$in thick plate of boron stainless steel sandwiched between two $\frac{3}{32}$in thick stainless steel plates. It is the boron that restricts the atomic fission process and provides control.

Motion of the rod is accomplished by the combined use of an electro-mechanical drive unit and hydraulic pressure. The portion of the drive line that moves during a scram consists of the control rod, seal shafting, safety latch, hydraulic piston rod and hydraulic piston. These scram components are held against the underside of the drive carriage during normal positioning by the force of reactor pressure acting on the area of the seal shaft, and will, therefore,

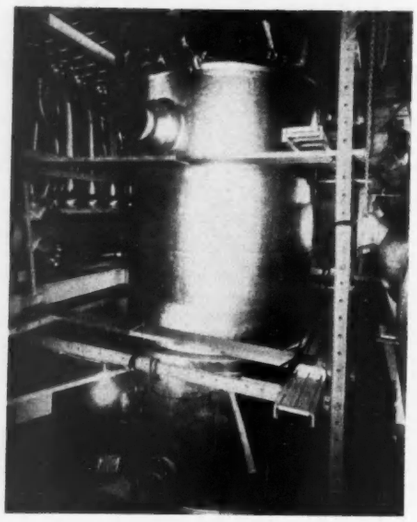


Fig. 12—Erection of reactor pressure vessel within the containment vessel

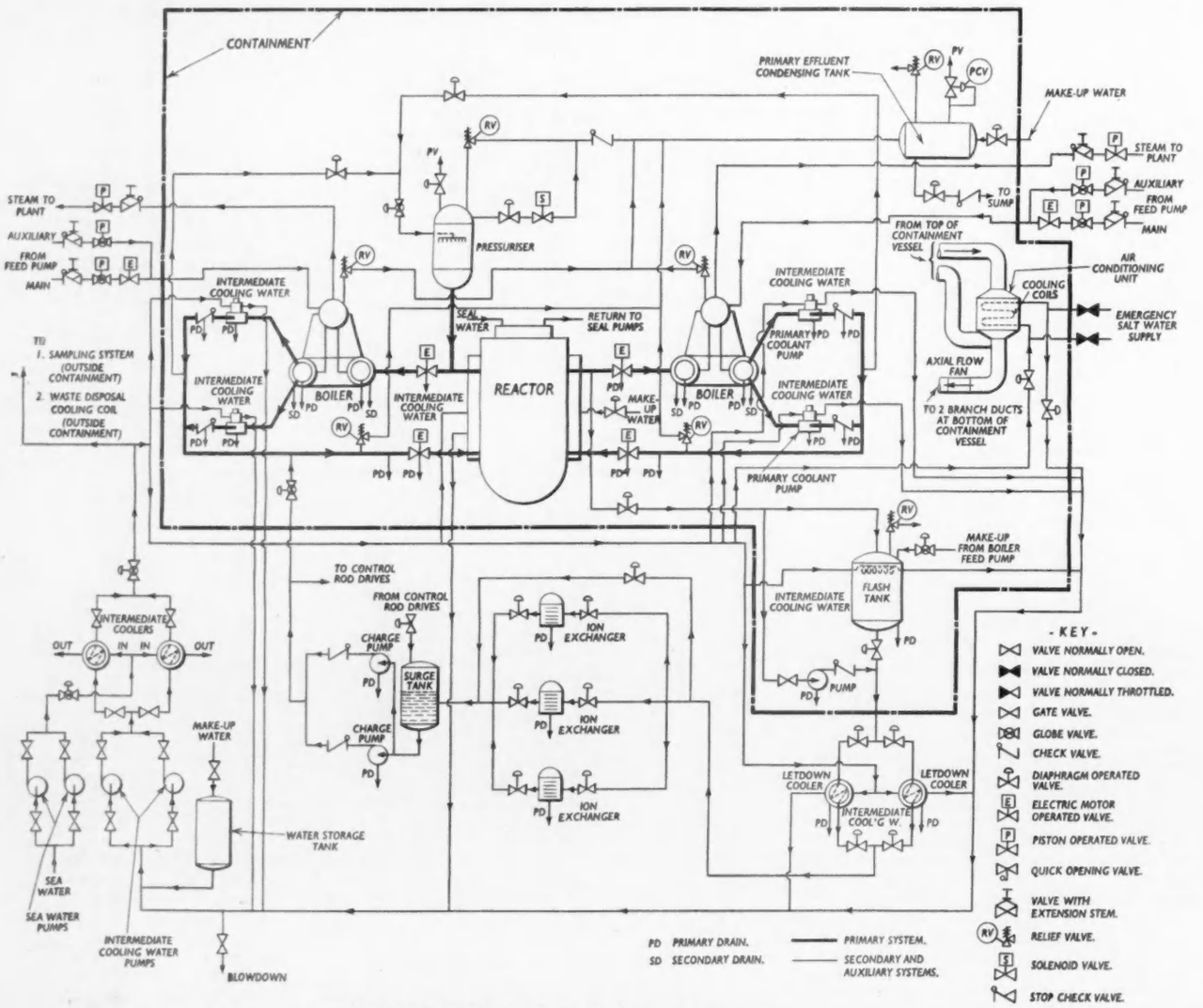


Fig. 13—Flow diagram of pressurised water reactor system

follow the carriage. The carriage is positioned by twin lead screws driven by an electric drive motor. The hydraulic pressure necessary for a scram is maintained continuously in a scram accumulator. Each rod has its own accumulator; each of these acts independently of the others. The scram pressure is held in check by a pilot-operated scram valve. By release of the pilot pressure, the full scram accumulator pressure is applied to the piston. This results in a net downward force on the rod drive line sufficient to accelerate the rod into the core at the required rate.

There is a safety latch on the rod drive which will not allow it to be withdrawn unless it is in contact with the drive mechanism. Consequently, under no circumstances can the reactor pressure or the hydraulic piston withdraw a rod at a faster rate than the driving carriage will allow, and once a control rod has been driven in by a scram, it cannot be withdrawn until the drive carriage has been moved down to release its latches. The safety latch will also hold the rods in position within the core in the event of a capsized ship.

Control and Safety System

The automatic control system is designed to adjust the reactor power level to meet the steam load requirement. The system also maintains the average reactor temperature at 508 deg. Fah. The average temperature is maintained independent of reactor power level. Variations in coolant temperature and steam flow are detected by sensors which supply corrective action to the control rods. This corrective signal, or power error, initiates the movement of a rod group with a velocity proportional to this error up to a preset velocity limit. This maximum velocity will limit the reactivity insertion rates to a safe value and still permit rapid manœuvring of the plant. The control system prevents excessive transients in the primary coolant temperature during demand load changes.

The reactor safety system monitors signals from the nuclear and non-nuclear instrumentation to detect unsafe conditions and initiates corrective action as necessary. Two modes of corrective action, scram and fast insertion, are initiated by the safety system depending upon the nature of the abnormal condition. For scram action, all withdrawn control rods are rapidly inserted into the core by the hydraulic pressure in about 1·6 seconds. During a fast insertion, all withdrawn rods are inserted at the maximum rate available through the electro-mechanical drive, about 15in per minute. A scram signal overrides all signals while a fast insertion signal will override all automatic control or manual rod signals. The reactor safety system is designed to protect the reactor from damage during all abnormal conditions with the exception of a major rupture in the primary system. The number of scram signals has been kept to the minimum consistent with the philosophy of reactor protection. To minimise spurious scrams due to minor malfunctions, a coincidence of unsafe indications from two independent instruments is utilised wherever possible. The safety system also contains a group of annunciator signals. These signals warn operators when any system parameter is outside its normal operating range allowing corrective action to be taken before a serious condition arises.

Primary Reactor System

The function of the primary system is to transfer the heat generated in the reactor core to the steam generators (Fig. 13). Demineralised water is circulated through the reactor and boilers by means of two closed loops. Each loop contains two circulating pumps, one steam generator, two check valves and two stop valves together with the necessary piping. The system is designed to transfer 74MW or 252·6 million B.Th.U per hour from the reactor core at full load with a flow rate of 8,000,000 lb per hour. The inlet temperature to the reactor at this power level is 494·7 deg. Fah. and the outlet temperature is 521·3 deg. Fah. The heat added to the water as it flows through the reactor is given up in the steam generators.

All material in contact with the reactor coolant water in the primary system is 18-8 stainless steel. The primary loop water is pressurised to 1750 lb per square inch by an electrically heated pressuriser vessel in which normal operating conditions are automatically maintained by the alternate use of electrical heaters or spray coolers. The water level in the pressuriser is maintained by regulating the rate of primary loop water flow to the purification system, the recharging flow to the purification system and the recharging flow introduced by the charge pumps. Water in the primary loop is circulated by four canned-rotor pumps, each with half and full-speed windings. The system is designed to use all four pumps at full speed during normal operation of the power plant. Their main design characteristics are 230 h.p., 5000 gallons per minute at 495 deg. Fah., at 70 lb per square inch head.

The main primary piping is 12 $\frac{9}{16}$in inside diameter, and the branch piping between the boiler outlets and the Y fittings, containing the pumps, is 8 $\frac{9}{16}$in inside diameter.

Secondary System

In the secondary system feed water is heated to steam in two steam generators. Each steam generator consists of a U tube, U shell lower drum with the primary piping connecting to the inlet and outlet nozzles on the heads of the drum. The shell side is connected to an upper drum, situated on the centre line and above the lower drum, by means of thirteen risers and eight downcomers. The risers and downcomers are designed to ensure natural circulation at all loads and attitudes of the ship.

Cyclone separators and scrubbers are provided in the upper drum to supply dry saturated steam at the outlet nozzles. The steam quality will be maintained at approximately 0·25 per cent moisture. The steam generators are designed for 2000 lb per square inch gauge on the tube side and 800 lb per square inch gauge on the shell side. The design temperature for the tube and shell sides is 650 deg. Fah.

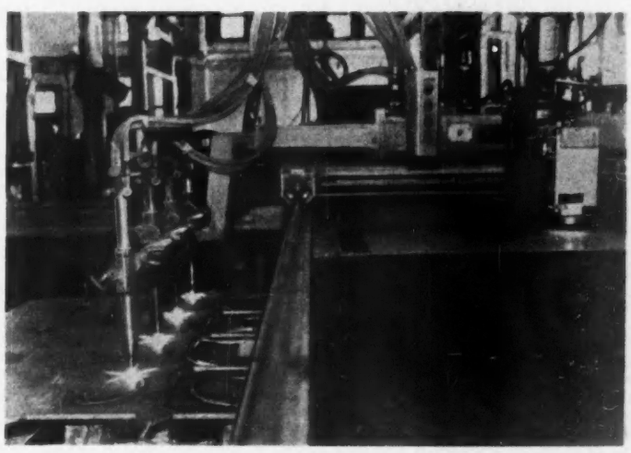
(To be continued)

Oxygen Cutting Machine With Electronic Tracer

Simple pencil-line sketches of intricate shapes and forms can now be used to guide oxygen shape-cutting machines. A new electronic tracer has been introduced by the Linde Division of the Union Carbide Corporation, of New York, which allows pencil or ink-line drawings to control single or multiple-torch flame-cutting machines. A built-in automatic kerf compensator makes it possible to reproduce one or thousands of complicated metal parts easily and with extreme accuracy from exact-size drawings. The automatic kerf adjustment represents an improvement over existing tracing units, since parts can now be reproduced without the necessity of making allowance for kerf width on the drawing.

Known as the Linde Photocell Tracer, the new unit eliminates the need for expensive metal or plastics templates, photographic negatives or complicated and costly silhouettes. The drawings of parts are made in the exact size of the part desired. The kerf compensator dial is then set for the plate thickness being cut and automatically compensates for kerf width so that the reproduced parts are exactly the same size as the line drawing. The preparation of the pencil or ink-line drawings that guide the photocell tracer is extremely simple. The tracing accuracy is claimed to be excellent, and intricate metal shapes and small holes that cannot be cut using present mechanical tracing heads, can be cut easily. Shape-cutting can be done anywhere regardless of lighting conditions. The tracing speed is controlled by an eddy-current governor which provides smooth, stepless speed control over a speed range adjustable from 2in to 30in per minute. At average cutting speeds, the tracer can negotiate 90 deg. turns with a $\frac{1}{16}$in radius.

With the new tracer it is possible to use line drawings that will make the cutting torches move from one series of cut shapes to another, without interruption, for "chain" cutting. It is also possible to operate the new unit manually by using a steering knob. The heart of the new machine is a photo-electric scanning head geared to a steering motor which, in turn, is connected by means of a geared belt to the drive head. The main control box can be remotely mounted and is connected to the tracing head by a 25ft multi-conductor cable. A small remote control box is also provided.



Linde photocell tracer in use on a multiple-torch oxygen cutting machine

High-Temperature Insulation

Recent discoveries at Bell Telephone Laboratories indicate that fluoride coatings can be formed on copper, aluminium and other metal wires to provide exceptionally high insulation value at elevated temperatures, while retaining flexibility and freedom from porosity.

According to a paper by Drs. Steward S. Flaschen and Paul D. Garn, which was presented to a meeting of the American Ceramic Society in Chicago, the insulating coatings are formed directly on freshly cleaned copper or aluminium by exposing them to oxidising carriers of fluorine such as hydrogen fluoride or elemental fluorine at temperatures from 300 deg. to 600 deg. Cent. The thickness of the resulting copper fluoride and aluminium fluoride films depends on the temperature at which they are formed, the concentration of fluorine and the time of exposure. Aluminium forms a fluoride film 1 micron thick in a few minutes at 550 deg. Cent. These films remain adherent when bent repeatedly.

Electrical insulation values are very high for both copper and aluminium films, being in the order 10^{10} and 10^{11} ohms at room temperature for films in the order of 1 to 2 microns thick, between probe electrodes $\frac{1}{4}$in in diameter. The films retain their excellent insulating properties at high temperatures. For example, aluminium fluoride films exhibit resistances of about 7 by 10^{8} ohms at temperatures as high as 500 deg. Cent. The aluminium fluoride films show excellent resistance to oxidation even above 600 deg. Cent. They also show no tendency to hydrate or dissolve on exposure to high humidity. The insulation does not break down even at 450V at 500 deg. Cent.

The best organic insulating coatings cannot be used continuously above 300 deg. Cent. Inorganic insulators are generally porous and non-flexible, although some may be used as high as 830 deg. Cent. Insulating fluoride coatings should be satisfactory almost up to the melting point of the conductor. The technique is not limited to copper and aluminium, it is claimed.

Personal and Business

Appointments

MR. N. R. KIRKBY has been appointed general sales manager of Croda, Ltd.

MR. J. M. S. COATES has been appointed a director of George Angus and Co., Ltd.

MR. R. T. BROMFIELD has been appointed managing director of Invicta Electrodes, Ltd.

MR. F. W. STOKES has been appointed a director of Powell Duffryn Carbon Products, Ltd.

ASSOCIATED COMMERCIAL VEHICLES, Ltd., announces that Mr. H. E. Ells has assumed control of all publicity matters affecting the A.C.V. Group.

MR. F. DONACHY has been appointed a part-time member of the British Transport Commission, in succession to Captain Sir Ian Bolton, Bt.

MR. C. D. EDSFORTH has been appointed vice-president, traffic, Canadian Pacific Railway, in succession to Mr. G. F. Buckingham, who has retired.

LONDON MIDLAND REGION, BRITISH RAILWAYS, has announced the appointment of Mr. J. K. Lord as electrical traction engineer, Liverpool, in succession to Mr. R. C. Smith, who has retired.

MR. NORMAN READMAN, managing director of The Consolidated Pneumatic Tool Company, Ltd., has been appointed chairman of The Jacobs Manufacturing Company, Ltd., Frank Guylee and Son, Ltd., and the Reichdrill Manufacturing Company, Ltd.

MR. G. B. PERRY has been appointed managing director of Axia Fans, Ltd. He has also been appointed a director of Vent-Axia, Ltd., and will retain his seat on the board of Thermotank, Ltd. Consequent upon Mr. Perry's appointment, Mr. R. C. Adie has become general manager of the international products division of Thermotank, Ltd., and Mr. H. J. Watson, general manager of the engineering division.

Business Announcements

ALLEY AND MACLELLAN (Polmadie), Ltd., Glasgow, S.2, states that its telephone number has been changed to Pollock 6633 (8 lines).

WEST'S PILING AND CONSTRUCTION COMPANY, Ltd., announces that the new address of its Scottish office is 181/183, West George Street, Glasgow, C.2.

STUART DAVIS, Ltd., Much Park Street, Coventry, has been granted the sole selling agency in the United Kingdom for Johansson cylindrical grinding machines.

THE GENERAL ELECTRIC COMPANY OF IRELAND, Ltd., announces that its new premises at Adelaide Road, Dublin, were officially opened on Monday, September 7.

SHERBOURNE ENGINEERING, Ltd., Acocks Green, Birmingham, announces that its telephone number has been changed from Acocks Green 0683 to Acocks Green 5501 (14 lines).

THE ENGLISH ELECTRIC COMPANY, Ltd., announces that the address of its Bristol branch office is now Equity and Law Building, 36/38, Baldwin Street, Bristol, 1 (telephone : Bristol 27304).

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that from Monday, September 28, the address of its Northampton depot will be 18/22, St. George's Street, Northampton (telephone : Northampton 1860).

ALFRED BULLOWS AND SONS, Ltd., has made an agreement with the Gray Company, Inc., of Minneapolis, U.S.A., whereby it has sole distribution rights in the United Kingdom for " Graco " industrial equipment.

TEDDINGTON INDUSTRIAL EQUIPMENT, Ltd., Sunbury-on-Thames, Middlesex, states that it has appointed Aviation Electric, Ltd., Montreal P.Q., as exclusive distributor of Teddington engine protection equipment for the Dominion of Canada.

BRITISH WELDING RESEARCH ASSOCIATION announces the introduction of a new members' service department combining the functions of the old liaison and publications departments. Head of the new department is Mr. P. H. R. Lane, B.Sc. (Eng.), A.I.M., A.M.Inst.W., until recently deputy chief metallurgist of the association. Mr. R. G. Burt, O.B.E., B.Sc. (Eng.), M.I.Mech.E., M.Inst.W., hitherto chief development officer, remains with the association as development consultant, and Mr. L. Parkes has taken over as editor for reports and publications.

MR. H. R. E. SURRIDGE, managing director of Surridge's Patents, Ltd., Croydon Road, Beckenham, Kent, is to leave London for New York on September 21, for an export tour for " Holdtite " and " Titebond " industrial adhesives and stick-on soles. The tour will include visits to Venezuela, Trinidad and Jamaica.

POLLARD BEARINGS, Ltd., Ferrybridge, Yorkshire, has opened a French branch office, Pollard-Roulements, 98, rue Truffaut, Paris, 17e (telephone : Marcadet 09–10). Canadian Pollard Bearings, Ltd., Oakville, Ontario, is to open a branch office in Montreal at 623, Decarie Boulevard, Ville St. Laurent, P.Q.

Contracts

THE ROYAL NORWEGIAN NAVY has placed an order with Solartron Radar Simulators, Ltd., for a six target radar simulation system.

PLATT BROTHERS (SALES), Ltd., Oldham, a subsidiary of Stone-Platt Industries, Ltd., has secured a contract from the U.S.S.R. for woollen spinning machinery to the value of over £250,000.

THE MINISTRY OF SUPPLY announces that a contract has been placed with Hawker Siddeley Aviation for twenty Armstrong Whitworth " 660 " tactical freighter aircraft, for use in R.A.F. Transport Command.

WORTHINGTON-SIMPSON, Ltd., has been awarded a contract by the Central Electricity Generating Board for the design, supply and erection of condensing plant for two 300MW turbo-generators to be installed at West Thurrock power station, Essex. Each plant includes one condenser having a total cooling surface area of 165,000 square feet, three 50 per cent capacity horizontal extraction pumps and four 33⅓ per cent capacity hydraulic rotary air pumps, together with all associated piping and valves. Each condenser is designed to condense approximately 1,280,000 lb per hour of steam at an absolute pressure of 1·1 Hg when supplied with 135,000 gallons per minute of circulating water at 55 deg. Fah. The extraction pumps each have a capacity of 1270 gallons per minute against a total head, including vacuum, of 260ft.

Miscellanea

ENGINEERING INDUSTRIES ASSOCIATION.—The annual exhibition of the Engineering Industries Association is to be held at the Royal Horticultural Society's New Hall, London, S.W.1, from Tuesday, October 20, to Thursday, October 22, inclusive. This year the products of some 130 companies will be displayed.

FLEXIBLE SHAFT MACHINE.—A new flexible shaft machine for use with rotary tools such as files, cutters, brushes, &c., has been introduced by B. O. Morris, Ltd., Coventry. This machine has a ½ h.p. motor and drive is transmitted through a gearbox giving three speeds of 3000, 9000 or 15,000 r.p.m. Three shaft take-off drives are incorporated so that a succession of tools can be used without need for tool changing between operations.

LARGE ANCHOR WINDLASS.—A large steam-driven anchor and mooring windlass of totally enclosed design and weighing 40 tons has been completed by the Telegraph Construction and Maintenance Company, Ltd. The power unit consists of a double-cylinder steam engine designed to lift two anchors, each weighing 9½ tons and handle 3in steel cable, and be capable of exerting a pull of 12 tons at 100ft per minute on the mooring ropes.

TOOL FOR STRAIGHTENING SCAFFOLDING TUBES.—A portable hydraulic tool is made by Chamberlain Industries, Ltd., Staffa Works, Staffa Road, Leyton, E.10, for straightening bent scaffolding tubes on site. The machine is a small, compact hand-operated hydraulic unit with a capacity of some 7 tons. The combined pump and ram have a screwed cylinder end which allows special purpose tools or adaptations to be fitted for odd jobs on site.

GUIDE TO PROSPECTIVE EXPORTERS.—A new publication of the Gauge and Tool Makers' Association, Standbrook House, Old Bond Street, London, W.1, is entitled " A Simple Guide to Prospective Exporters." This booklet has been produced to assist firms wishing to enter the field of overseas trading for the first time. The subjects dealt with include representation in foreign markets, how to appoint an agent, methods of exporting, methods of payment, &c. Copies of the publication are available at 3s. 6d. each, on application to the association.

PLASTIC ALUMINIUM.—An addition to the range of Devcon plastics metal products distributed in Great Britain by E. P. Barrus (Concessionaires), Ltd., Acton, London, W.3, is a material of liquid consistency containing 80 per cent aluminium. The matrix is not volatile, so that the cast hardens without shrinking ; this takes one and a half to two hours at 70 deg. to 75 deg. Fah. The hardened material can be machined as metal, and a polished finish is obtainable : if the liquid is used as paint, it will tolerate normal baking temperatures.

INSTITUTION OF MINING AND METALLURGY.—Professor David Williams, D.Sc., Ph.D., B.Eng., D.I.C., who occupies the University of London Chair of Mining Geology at the Imperial College of Science and Technology, has been elected President of the Institution of Mining and Metallurgy for 1960-61. He was elected to Associate Membership of the Institution in 1932, to full membership in 1941, and has served on the Council since 1949, holding office as Vice-President from 1954 to 1957. He will take office in May, 1960, in succession to Dr. J. H. Watson, C.B.E., M.C.

PREFABRICATED VAN BODY.—Aluminium platform bodies for commercial vehicles have for some years been available in kit form for assembly by relatively unskilled labour. This principle has now been applied to van bodies by Northern Aluminium Company, Ltd., and a prototype has been completed by Willowbrook, Ltd., Loughborough. The floor of the van is of Noral extruded planks (see page, 521, October 12, 1956) and the walls and roof of aluminium alloy sheets riveted to extruded stiffeners. A variety of rear door arrangements would, it is contemlpated, be available to purchasers of kits.

MERCURY-POOL IGNITRONS.—A range of mercury-pool ignitron tubes for the control and rectification of heavy alternating currents has been introduced by Mullard, Ltd., Mullard House, Torrington Place, London, W.C.1. The range comprises five tubes, all interchangeable with internationally available equivalent types. Four of the tubes are intended primarily for welding control circuits, furnace control and similar applications, while the fifth is designed specifically for power rectification, and has limited applications in a.c. control. The tubes are water cooled and have stainless steel water jackets and cooling sections to avoid corrosion.

FLOOR FINISHES FOR FACTORIES.—The Building Research Station has published a brochure entitled " Floor Finishes for Factories " (H.M. Stationery Office, price 1s. 9d.) in its series of factory building studies. It is pointed out that for both managements and building designers, factory floor finishes present many problems and it is important to consider the conditions of use as well as initial and probable subsequent maintenance costs. The brochure explains these points in relation to general-purpose floors and in relation to finishes for certain special purposes, namely, dust-free floors, floors with high-impact loads, spark-free floors, and chemically-resistant floors.

THREAD CHECKING AND IDENTIFICATION.—A means for checking and identifying screw threads is now being supplied by F. Miller and Co. (London), Ltd., Cambridge Avenue, Trading Estate, Slough, Bucks. This means comprises a strong double-sided board, one side of which has secured to it on engraved identifying panels threaded male and female units covering all sizes of Whitworth, B.S.F., U.N.C., and U.N.F. threads from ¼in to ½in diameter and 0 to 8 B.A. inclusive. Male or female components can be screwed into these units when it is required to classify the threads upon them. On the reverse side of the board there are detailed standard types of screw and bolt heads, patent lock nuts, washers, and the popular kinds of plating used.

HIGH-PRESSURE HYDRAULIC FITTINGS.—Amongst recently introduced high-pressure fittings manufactured by the Oil Feed Engineering Company, Ltd., Herga House, Vincent Square, London, S.W.1, is a valve for isolating high-pressure circuits which can be supplied with either hand-wheel or cam operation. It employs metal seatings and incorporates a special unloader device which enables the valve to be used for pressures up to 7500 lb per square inch. The model is available with ¼in B.S.P. inlet and outlet threads and has a total height of 5¾in. Compact swivel connections for operation at pressures up to 4500 lb per square inch have been added to the firm's " Hi-Flex " range of hoses and fittings. The swivel unions employ hydraulically balanced seals which may be easily replaced. The joints made in ¼in to ½in and in 1in B.S.P. thread sizes can be swivelled through 360 deg.

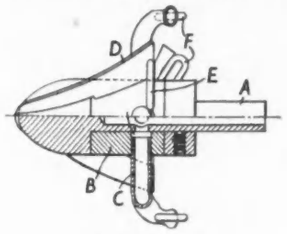
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings, unless otherwise stated. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

COAL BUNKERS

816,481. September 3, 1957.—DEVICE FOR TRIMMING COAL BUNKERS, Central Electricity Generating Board, Central Electricity House, Trafalgar Buildings, London, S.W.1, and Frederick Ratcliffe, 179, Hillbury Road, Warlingham, Surrey.

This invention relates to a device for trimming coal in bunkers and like purposes, such as the clearing of choked coal chutes and the freeing of large pipes obstructed by masses of coal or similar material.



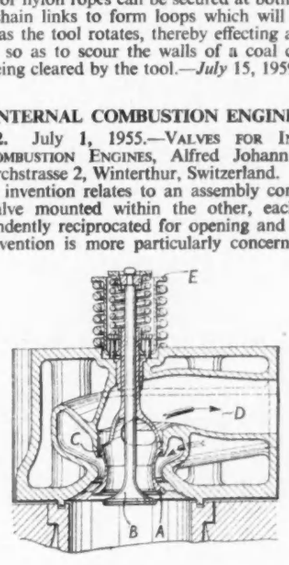
No. 816,481

It comprises a tubular fitting *A* with a nosepiece and having mounted upon the shank a rotatable tool on a hub *B* retained by a collar and grub-screws. The tubular fitting can be connected to a source of compressed air by a tube or a flexible hose by which it can be lowered down a large pipe to be cleared of obstruction. The bore of the nose hub is recessed to provide an annular groove registering with a number of ports drilled radially through the wall of the shank. Four small tubes *C* secured upon the hub connect with the annular groove and shank interior. These small tubes are curved at their outer ends in a circumferential direction, so that the flow of compressed air through them will cause the rotation of the hub by the reaction of the air jets exhausting from the ends. The rotatable tool has four blades *D* extending over the stationary nosepiece, which are adapted to cut into the material into which the tool is inserted. The effective boring diameter of the blades is small at the leading end of the tool but increases sharply up to a maximum in approaching the radial tubes. The blades may be shaped helicoidally so as to screw into the material in the manner of an auger, or in the opposite sense so as to exert a "ploughing" action, the material being then thrown outwards by centrifugal effect. For the attachment of chains or ropes to the tool, so as to assist the action of the blades, the hub is fitted with four oval chain links *E* between the radial tubes. Four other chain links *F* are welded to the outer portions of the radial tubes and loose chains or nylon ropes can be secured at both ends to these chain links to form loops which will fly outwards as the tool rotates, thereby effecting a flaying action, so as to scour the walls of a coal chute or pipe being cleared by the tool.—*July* 15, 1959.

INTERNAL COMBUSTION ENGINES

816,392. July 1, 1955.—VALVES FOR INTERNAL COMBUSTION ENGINES, Alfred Johann Buchi, Archstrasse 2, Winterthur, Switzerland.

This invention relates to an assembly comprising one valve mounted within the other, each being independently reciprocated for opening and closing. The invention is more particularly concerned with

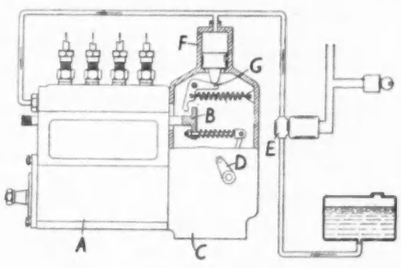


No. 816,392

the admission and exhaust valves for internal combustion engines although the invention is not so limited. The accompanying drawing shows a sectional elevation of the cylinder head of an engine incorporating a valve assembly. The inlet valve *A* is the outer valve referred to above and the inner valve is indicated at *B*. Air or air-fuel mixture is supplied to the engine through the duct *C* and passes around the outer valve *A* into the cylinder. The exhaust gases pass from the cylinder through the outer valve and then through the exhaust duct *D*. The outer valve is hollow and bell-shaped with a domed head portion provided with triangular openings through which the exhaust gases from the cylinder are discharged when the poppet valve *B* is open. The tubular stem of valve *A* has secured to it a cup member *E* against which a coiled spring bears to hold the valve against its seat and close the admission duct *C*. The inner valve *B* is provided with a split-ring cotter engaged by a coiled spring that holds the valve in its closed position. Valve gear of any known or convenient construction is provided to reciprocate the valves.—*July* 15, 1959.

816,449. February 24, 1958.—FUEL SUPPLY SYSTEMS FOR INTERNAL COMBUSTION ENGINES, C.A.V., Ltd., Warple Way, Acton, London, W.3. (*Inventor: Wilfrid Edward Walter Nicolls.*)

This invention relates to fuel supply systems for internal combustion engines, comprising an injection pump driven by the engine and a feed pump which supplies the fuel to the injection pump from a supply tank. In the event of the tank being emptied by the feed pump while the engine is running, a risk is incurred of air being drawn into the system, and the object of the invention is to provide a system which automatically stops the engine immediately the supply to the feed pump ceases. In the example illustrated, the engine-driven injection pump *A* has a fuel control member *B* operable by a governor *C*



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for controlling the quantity of fuel delivered. A manual lever *D* is provided for moving the control *B* into such a position that no fuel is delivered by the pump when it is desired to stop the engine. The injection pump is supplied by an independent motor-driven feed pump *E* from a supply tank. A cylinder *F* contains a piston arranged to act on a lever *G* which is loaded by a spring. The cylinder is connected to the fuel pipe between the two pumps. When the feed pump is in motion the pressure of the fuel acting on the piston moves the lever *G* to an inoperative position. In this condition, the injection pump is controlled by the normal action of the governor, or the lever. In the event of the tank being emptied while the engine is running, the pressure of the fuel in the pipe between the two pumps immediately drops, and the spring-loaded lever moves the control *B* to a position at which the injection pump ceases to deliver fuel to the engine, so preventing emptying of said pipe.—*July* 15, 1959.

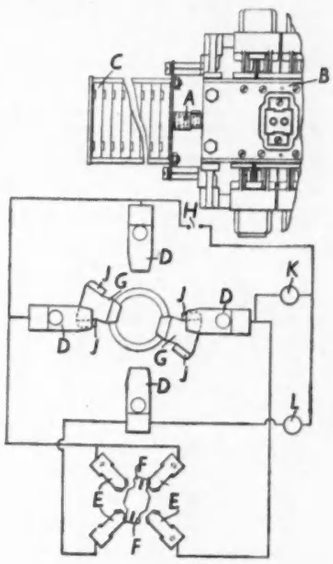
812,862. August 19, 1957.—MULTI-CYLINDER INTERNAL COMBUSTION ENGINE, General Motors Corporation, Grand Boulevard, Detroit, Michigan, U.S.A. (Assignees of John Dolza.)

It is characteristic of four-stroke cycle internal combustion engines to produce power more efficiently at high torque. To take advantage of this, it has been proposed to utilise less than the total number of cylinders in an engine to produce outputs which are less than maximum output, so that the cylinders are utilised operate at higher efficiencies. Thus, the number of effective cylinders brought into operation increases as the torque requirement increases. This, however, results in uneven engine wear and spark plug fouling. According to this invention, the engine includes a device which, in accordance with engine torque requirements, controls the number of cylinders to which fuel is supplied and which so shifts the fuel supply between the cylinders over a number of successive periods of operation with less than the maximum number of cylinders so that any one cylinder is not continuously operative during all the periods.—*May* 6, 1959.

ELECTRICAL ENGINEERING

813,127. July 29, 1957.—ROTARY ELECTRIC SWITCHES, Santon, Ltd., Somerton Works, Newport, Monmouth. (*Inventor: William Alan Bowdler.*)

This invention relates to rotary electric switch assemblies embodying a quick make-and-break action and driven by a spring mechanism at a rate irrespective of the action of the operator. Its purpose is to enable switching to be carried out in high-duty switches of this kind without an open circuit condition arising. A rotary electric switch assembly, according to the invention, comprises a primary



No. 813,127

switch having mounted coaxially therewith a secondary rotary electric switch, operating simultaneously with the primary switch. The stationary contacts of the primary switch are connected in parallel with corresponding contacts of the secondary switch, and it is arranged that as the break position approaches in the primary switch, the make position in the secondary switch is obtained, this condition remaining until such time as the rotating contacts in the primary switch are made, after which the secondary switch contacts are open circuited. The drawings show an elevation of part of a primary rotary switch with coaxial secondary switch, according to this invention, and a diagram of the contact members of the primary and secondary switches, showing the primary switch contacts still made, when the secondary switch contacts begin to make. The centre shaft *A* of the high duty rotary electric switch *B* has mounted coaxial therewith a smaller duty rotary electric switch *C*, the stationary contacts *D*, *E* of the two switches being connected in parallel. Rotary contacts *F* of the secondary switch are off-set in relation to the rotary contacts *G* of the primary switch, whereby these contacts *E*, *F* are completed and the circuit made before a break in the circuit controlled by the primary switch contacts is completed. When the switches are stationary, the load from a supply source *H* is carried by the contacts *D*, *G* of the primary switch, as the contacts of the secondary switch would not be in their made position. The rotary contact members of the primary or high-duty switch are provided with side extensions *J*, in order to meet certain switching applications, as, for instance, the timing of the make before break of the secondary switch with the primary switch. In operation, in, for instance, the transfer of a load from *K* to *L*, it will thus be seen that the main load is carried by the contacts of the secondary switch during the time that the contacts *G* in the primary switch are moving to the next position. As this time is only about ten milliseconds, there is no risk of the contacts in the secondary switch becoming over-heated.—*May* 6, 1959.

CASTINGS

813,504. May 1, 1956.—INVESTMENT CASTING MOULDS, The Fairey Aviation Company, North Hyde Road, Hayes, Middlesex. (*Inventor: Gerald Lyon.*)

This invention relates to methods of making investment casting moulds with refractory material in the form of a slip or slurry, then at least partly surrounding the coated pattern with additional material, and finally removing the pattern, for example, by melting. Small castings can be made in such moulds to within a few thousandths of an inch of that desired, and having a smooth enough surface

to avoid the necessity of machining. In some cases, and particularly with moulds for larger castings, for example, exceeding about 10in in maximum dimension, difficulties arise in maintaining the smooth surface of the cavity facing. According to this invention a method of producing an investment casting mould includes the step of coating a pattern with a slurry including fused silica. The expression "investment casting mould" is used in this specification to include part moulds which do not entirely surround the casting. It has been found that in many cases moulds made in accordance in this way have smooth surfaces which are maintained when metal is cast into the mould cavity. More than one coating of the slurry may be applied to the pattern and the proportion of fused silica in successive coatings may be progressively reduced.—*May* 21, 1959.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

ENAMELLED COPPER CONDUCTORS (ENAMEL WITH VINYL ACETAL BASE)

No. 1844. Part 2 : 1958. "Rectangular Conductors." Price 4s. 6d. With the publication of this new part, the scope of B.S.1844 has been enlarged to include rectangular conductors as well as round wire. The requirements and tests are similar to those for round wire in the current edition of B.S.1844, which now becomes Part 1 of the standard. It is stated that it has not been found possible to adopt standard sizes for rectangular conductors but a schedule of preferred sizes is given.

SINE BARS AND SINE TABLES (EXCLUDING COMPOUND TABLES)

No. 3064 : 1959. Price 4s. 6d. This specification provides for three types of sine bars in sizes of 4in, 5in and 10in and 100mm, 200mm and 250mm; and for sine tables inclinable about a single axis in sizes of 5in and 10in and 100mm and 200mm.

Requirements for general design and manufacture are confined to those essentials which affect performance, and recommendations for suitable heat treatments are included. Accuracy is fully specified on all functional elements in order to ensure that the sine bars and tables are suitable for use as precision equipment.

PREFERRED SIZES OF FIRECLAY REFRACTORIES

No. 3056 : 1959. Price 5s. In this publication, preferred nominal sizes are specified as a step towards simplification in the range of manufactured fireclay bricks and in their use in furnace construction. Based on a proposed range of sizes submitted by the National Federation of Clay Industries, the specification has had the full support of the Fireclay Refractories Industry—in which experience has been that the existing demand for a wide variety of sizes has resulted in short production runs on machines and frequent changing of moulds. The range of sizes in this standard forms part of a similar but somewhat more extended range issued by the Scottish Employers' Council for the Clay Industries.

It is considered that the selection of "preferred" sizes offered will meet most normal requirements, but it is not suggested that other types and sizes of firebrick will be unobtainable.

LAMINATED SPRINGS AND SPRING STEELS FOR RAILWAY ROLLING STOCK MATERIALS

No. 24, Part 3A : 1959. Price 7s. 6d. For the past four years the British Standards Institution has been revising B.S. 24, "Railway Rolling Stock Materials." Now, with the publication of Part 3A, the work has been completed and the whole series of parts reflects the present trend in railway rolling stock material throughout this country. The standards conform generally to the requirements of the British Transport Commission (although the Commission's internal standards do vary to a small extent from those issued by the B.S.I.). Sections 1 and 2 of this Part deal respectively with "Steels for Laminated Springs" and with "Steels for Buckles." They specify requirements for the steel making process, the tests required to determine the quality of the steel, the testing facilities, and the action which can be taken if defects are revealed after delivery. Section 1 also specifies the dimensions and rolling tolerances of the bars, together with the requirements for a cambering test. Section 3 deals with laminated springs. It specifies requirements for quality of material, assembly and scragging, method of gauging, tolerances on the finished springs and the load deflection test. Appendices specify the dimensions of the tensile test pieces, and tables of metric equivalents.

Launches and Trial Trips

ULSTER STAR, refrigerated cargo liner; built at Belfast by Harland and Wolff, Ltd., for the Blue Star Line, Ltd.; length between perpendiculars 490ft, breadth moulded 70ft, depth moulded to upper deck 38ft 3in, gross tonnage 10,500; six passengers; two complete steel decks, eight watertight bulkheads, six cargo holds, MacGregor steel hatch covers, two 10-ton, six 5-ton and twelve 3-ton derricks; four 400kW diesel-driven generators; Harland and Wolff opposed-piston, pressure-induction, single-acting, two-stroke engine, six cylinders of 750mm diameter by 2000mm combined stroke, 110 r.p.m. Trial, July 3.

AMAZON, passenger and cargo liner; built by Harland and Wolff, Ltd., at Belfast, for Royal Mail Lines, Ltd.; length between perpendiculars 540ft, breadth moulded 78ft, depth moulded to upper deck 41ft, gross tonnage 20,000; passengers, 107 first class, 82 cabin class and 275 third class, fully air conditioned; insulated cargo 435,000 cubic feet, two 15-ton, four 10-ton, two 7-ton and twelve 5-ton derricks, electric cargo winches; four 750kW diesel-driven alternators, one 400kW diesel-driven emergency alternator; two Harland and Wolff single-acting, two-stroke, opposed-piston engines, six cylinders, 750mm diameter by 2000mm combined stroke, 110 r.p.m. Launch, July 7.

Catalogues and Brochures

THE TYNE WIRE ROPE MANUFACTURING COMPANY, Ltd., Albert Terrace, South Shields.—Mining and engineering rope catalogue.

JOHN THOMPSON WATER TUBE BOILERS, Ltd., Wolverhampton.—Illustrated catalogue giving details of the "La Mont" waste heat boiler.

W. CROCKATT AND SONS, Ltd., Darnley Street, Glasgow, S.1.—Booklet giving technical details of electric salinometers and densometers.

JOHN THOMPSON ORDNANCE COMPANY, Ettingshall, Wolverhampton.—Catalogue dealing with nuclear fuel handling describing some charge face machinery.

JOHN THOMPSON (PIPEWORK), Ltd., Ettingshall, Wolverhampton.—Illustrated catalogue describing some of the recent pipework installations carried out by the company.

CIBA (A.R.L.), Ltd., Duxford, Cambridge.—Publication entitled "How to Use Araldite Epoxy Resin Adhesives," a guide to the materials which can be successfully bonded by "Araldite."

JOHN THOMPSON-KENNICOTT, Ltd., Wolverhampton.—Booklet giving descriptions of some of the main products of the company used in the treatment and purification of water. The booklet deals primarily with ion exchange.

ALBI-WILLESDEN, Ltd., 6, De Vere Gardens, London, W.8.—Illustrated brochure describing Albi-"R" fire-retardent coating, which can be applied to any combustible building material to provide fire protection and decoration.

W. C. HOLMES AND CO., Ltd., P.O. BOX No. B7, Turnbridge, Huddersfield.—Publication No. 97, describing the Holmes-Schneible "SW" cupola collectors, for the control of cupola emissions and reduction in atmospheric pollution.

GEORGE ANGUS AND CO., Ltd., Angus House, 152–158, Westgate Road, Newcastle upon Tyne, 1.—Booklet containing details and illustrations of gloves, mitts, handpads, fingerstalls and sleeves, designed for the protection of hands and arms.

JOHN THOMPSON INSTRUMENT COMPANY, Ltd., Ettingshall, Wolverhampton.—Booklet describing the "Sentinel" series 6in strip chart multi-point temperature recorder, and catalogue primarily concerned with the manufacture of complete panel installations.

EMIL JAGER KG, Dahlweg 105, Münster (Westphalia).—A leaflet describing the latest version of its range of "GSA" mesh welding machines, for widths of up to 2700mm in continuous or precut lengths, from wires of up to 12mm diameter. Sole U.K. agent: Frank Whitelegg, Ltd., 304, High Street, Sutton, Surrey.

E. LEYBOLD'S NACHFOLGER, Cologne-Bayenthal.—A brochure "Wegweiser durch das Hochvakuum-Programm" ("Guide to High Vacuum Equipment"), listing the firm's production of rotary vane and piston pumps, Roots pumps, oil and mercury vapour diffusion pumps, vacuum gauges and leak detectors, fittings, and complete plants for sputtering, distillation and freeze-drying. The last-mentioned class of plant are described in greater detail in separate pamphlets, "Gefriertrocknen" ("Freeze Drying") and "Lebensmittel Gefriertrocknen" ("Freeze Drying of Foodstuffs").

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF PUBLIC LIGHTING ENGINEERS

Tues. to Fri., Sept. 15 *to* 18.—Music Hall, Union Street, Aberdeen, Annual Conference.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., Sept. 14.—NORTH WEST LONDON BRANCH: Century Hotel, Wembley, Opening Meeting and Debate on Proposed Third Television Channel, 8.15 p.m. ★ BRISTOL AND WEST OF ENGLAND BRANCH: Grand Hotel, Bristol, Chairman's Address, and "Piped Television," D. C. Bishop, 8 p.m. ★ CENTRAL LONDON BRANCH: White Hall Hotel, Bloomsbury Square, London, W.C.1, "Development of Transistors," G. Grimsdell, 7.15 p.m.

Tues., Sept. 15.—ALDERSHOT AND DISTRICTS BRANCH: Queens Hotel, South Farnborough, Hants, "What Do You Know," and tape recording of A.S.E.E. Diploma Examination, 7.30 p.m. ★ YORK BRANCH: Visit to Derwent Plastics, Ltd., Stamford Bridge, 8 p.m.

Wed., Sept. 16.—WOLVERHAMPTON AND DISTRICT BRANCH: Chamber of Commerce, District Bank Chambers, Lichfield Street, Wolverhampton, "Electrical Aspects of High Frequency Heating," P. R. Harrison, 7.45 p.m. ★ NOTTINGHAM BRANCH: Mechanics Institution, Trinity Square, Nottingham, Chairman's Address, 7.30 p.m.

Fri., Sept. 18.—STOKE AND CREWE BRANCH: Royal Hotel, Crewe, "Floor Warming and Infra-Red Heating," C. J. Wheeler, 7.30 p.m.

Mon., Sept. 21.—BOURNEMOUTH BRANCH: Grand Hotel, Firvale Road, Bournemouth, "Wiring Cables," M. P. M. Rowe, 8 p.m.

Tues., Sept. 22.—NEWCASTLE UPON TYNE AND DISTRICT BRANCH: Crown Hotel, Clayton Street, Newcastle upon Tyne, "Magnetic Amplifiers," G. L. Horrobin, 7.30 p.m. ★ OXFORD AND DISTRICTS BRANCH: Employment Exchange, Oxford, "Electrical Safety in the Home," S. J. Emerson, 8 p.m. ★ PORTSMOUTH AND DISTRICT BRANCH: Offices of the Ministry of Labour and National Service, Lake Road, Portsmouth, "Fires and Explosions," S. J. Emerson, 7.30 p.m.

Thurs., Sept. 24.—BRIGHTON, HOVE AND DISTRICT BRANCH: New Imperial Hotel, First Avenue, Hove, "The I.E.E. Regulations for the Electrical Equipment of Buildings," S. J. Emerson, 7.30 p.m. ★ SOUTHAMPTON BRANCH: Polygon Hotel, Southampton, "Nuclear and Electrical Space Propulsion Systems," P. A. E. Stewart, 8 p.m. ★ SOUTH LONDON BRANCH: Greyhound Hotel, High Street, Croydon, Surrey, Film, "Power Under Control," 8 p.m.

BRITISH INSTITUTE OF MANAGEMENT

Mon., Sept. 21.—Recital Room, Royal Festival Hall, London, One-day Conference on "Knowing Your Customer," 9.30 a.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Sept. 30.—LONDON BRANCH: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Modern Microwave Valves: A Survey of Evolution, Principles of Operation and Basic Characteristics," W. E. Willshaw, 6.30 p.m. ★ TREFOREST BRANCH: Glamorgan College of Technology, Treforest, Glam, "The Use of Demonstration Equipment in Basic Radio Theory," H. Henderson, 6.30 p.m.

INDUSTRIAL WELFARE SOCIETY

Wed., Sept. 16.—Robert Hyde House, 48, Bryanston Square, London, W.1, "Changes in Industrial Law—The New Factories Act Explained," H. Samuels, 2.30 p.m.

Mon., Sept. 28.—Robert Hyde House, 48, Bryanston Square, London, W.1, "Changes in Industrial Law—the New Factories Act Explained," H. Samuels, 2.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., Sept. 23.—Constitutional Club, Northumberland Avenue, London, W.C.2, First Meeting of the 1959/60 Session, 7 p.m.

INSTITUTE OF PHYSICS

Wed. to Fri., Sept. 16 *to* 18.—STRESS ANALYSIS GROUP: The University, Birmingham, Annual Residential Conference.

INSTITUTION OF ENGINEERING DESIGNERS

Wed., Sept. 23.—YORKSHIRE BRANCH: Midland Hotel, Bradford, Yorks, "Stress Analysis as Applied to Design," J. Ward, 7.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Tues., Sept. 22.—Grand Council Chamber, The Federation of British Industries, 21, Tothill Street, Westminster, London, S.W.1, General Meeting: Presidential Address, R. A. Smeddle, 5.30 p.m.

INSTITUTION OF PLANT ENGINEERS

Wed., Sept. 16.—KENT BRANCH: Kings Head Hotel, High Street, Rochester, "Industrial Law and the Engineer," R. Cambridge, 7 p.m.

Thurs., Sept. 17.—BLACKBURN BRANCH: Castle Hotel, Blackburn, Joint Meeting with the Institute of Fuel, "Films and Lectures," E. A. Taylor, 7.30 p.m.

Tues., Sept. 22.—SOUTH WALES BRANCH: South Wales Engineers' Institution, Park Place, Cardiff, Technical Films, 7.30 p.m.

Thurs., Sept. 24.—GLASGOW BRANCH: Scottish Building Centre, 425/427, Sauchiehall Street, Glasgow, "Basic Electronics in Industry and Commerce," R. H. Garner, 7.15 p.m. ★ MERSEYSIDE AND NORTH WALES: Exchange Hotel, Liverpool, "Mounting and Maintenance of Roller Bearings," E. Taylor, 7.15 p.m. ★ NORTH-EAST BRANCH: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "The History and Development of Rotary Air Compressors," 7 p.m. ★ SHEFFIELD AND DISTRICT BRANCH: Grand Hotel, Sheffield, "Rolling Plant," P. A. Clark, 7.30 p.m.

Fri., Sept. 25.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Works Engineering," R. T. Wells, 7.30 p.m.

Mon., Sept. 28.—WEST AND EAST YORKSHIRE BRANCH: Houldsworth School of Applied Science, The University, Leeds, "Operational Research," G. D. Jordan, 7.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Sept. 14.—SHEFFIELD GRADUATE SECTION: Rothervale Manufacturing Company, Ltd., Woodhouse Mill, Near Sheffield, "Production Joinery," 6.45 p.m.

Thurs., Sept. 17.—WOLVERHAMPTON GRADUATE SECTION: Works Visit to Joseph Lucas, Ltd., Great King Street, Birmingham, 2 p.m.

Thurs., Sept. 24.—HALIFAX AND HUDDERSFIELD SECTION: Visit to T. S. Harrison and Sons, Ltd., Union Street, Heckmondwike, 6.30 p.m.

Wed., Sept. 30.—SHREWSBURY SECTION: Technical College, Shrewsbury, "Uses and Developments of Work Study," W. C. Castledine, 7.30 p.m. ★ LOUGHBOROUGH COLLEGE STUDENT SECTION: Visit to J. Lucas, Ltd., S. Block Restaurant, Farm Street, Hockley, Birmingham, 2 p.m.

NATIONAL ASSOCIATION OF DROP FORGERS AND STAMPERS

Wed., Sept. 16.—Botanical Gardens, Birmingham, One-day Symposium on "Spark Machining."

PHYSICAL SOCIETY

Mon. and Tues., Sept. 14 *and* 15.—Department of Natural Philosophy, The University, Edinburgh, Conference on "Nuclear Physics," 9.30 a.m.

Thurs. and Fri., Sept. 17 *and* 18.—Imperial College, The University of London, Conference on "The Physics of Very High Temperatures," 9.30 a.m.

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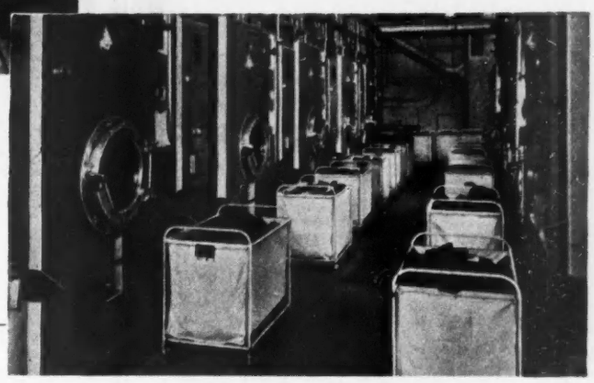

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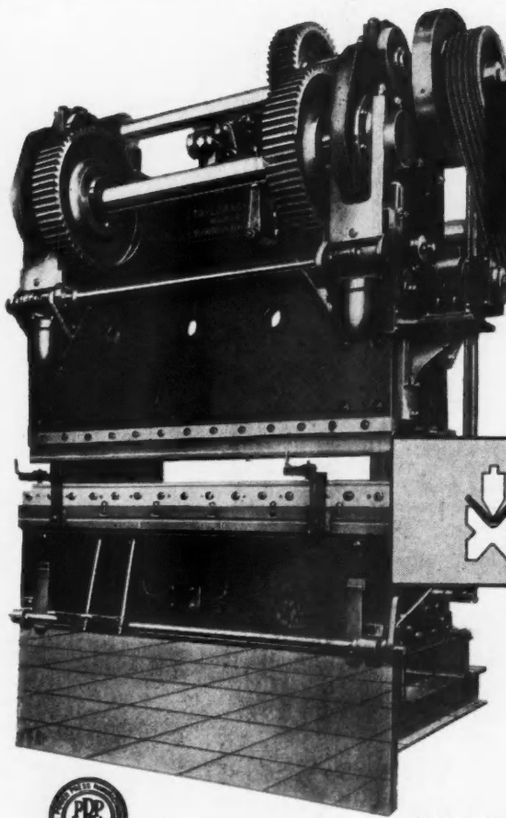

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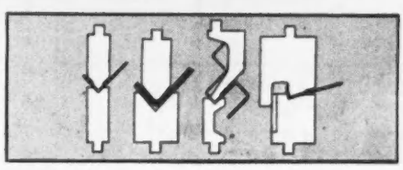

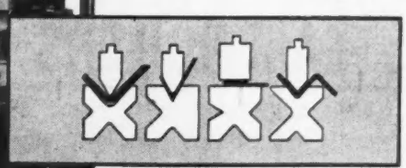

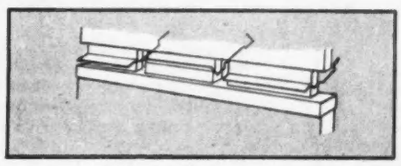

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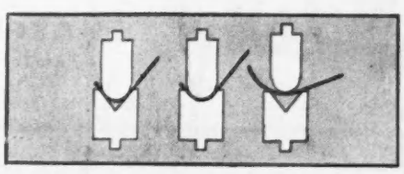

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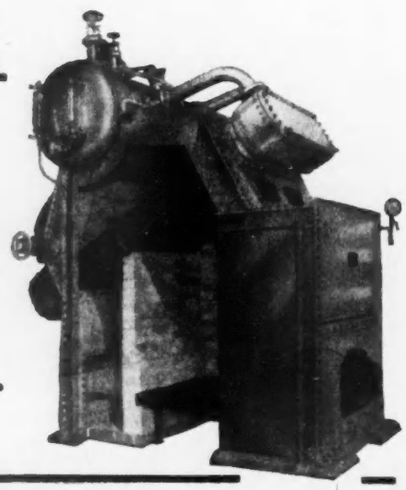

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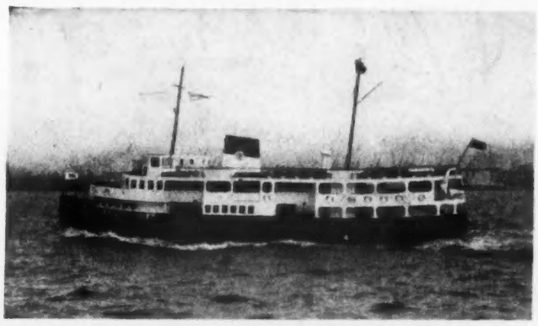

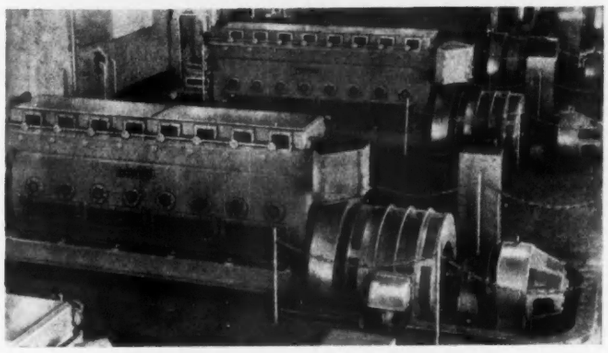

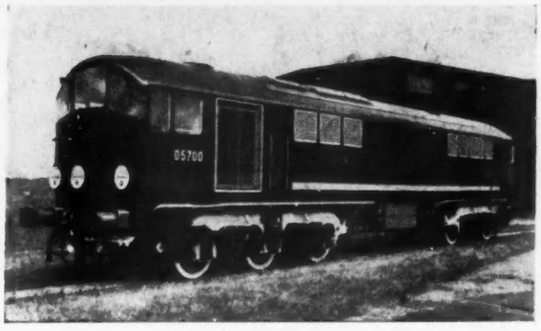

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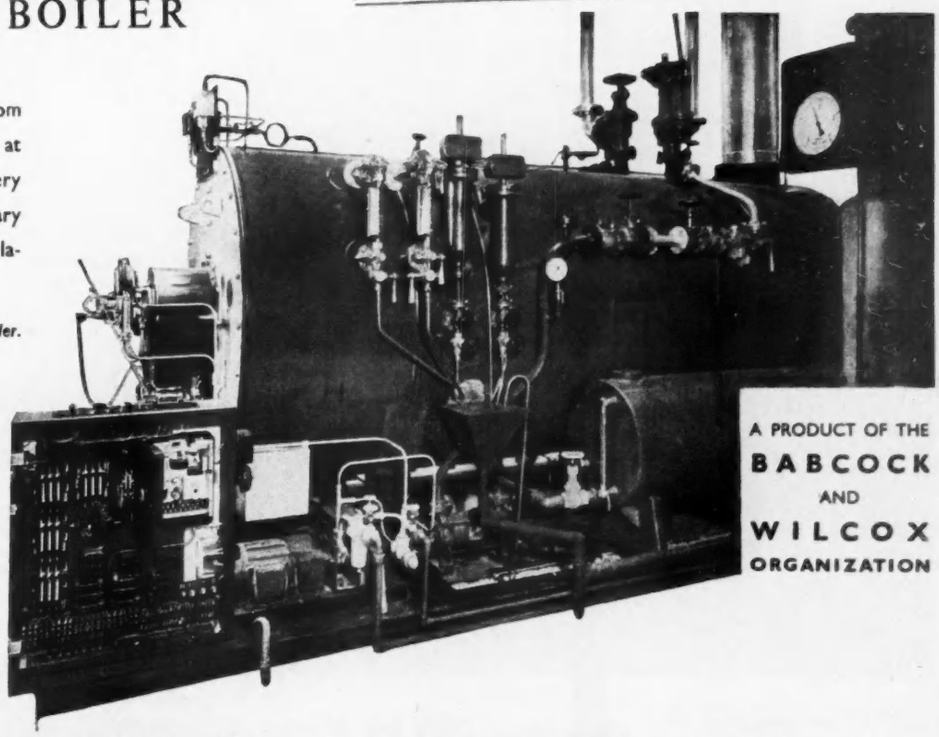

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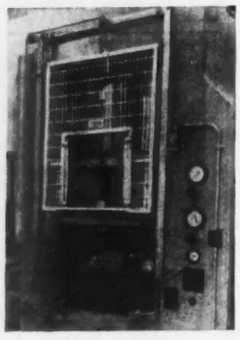

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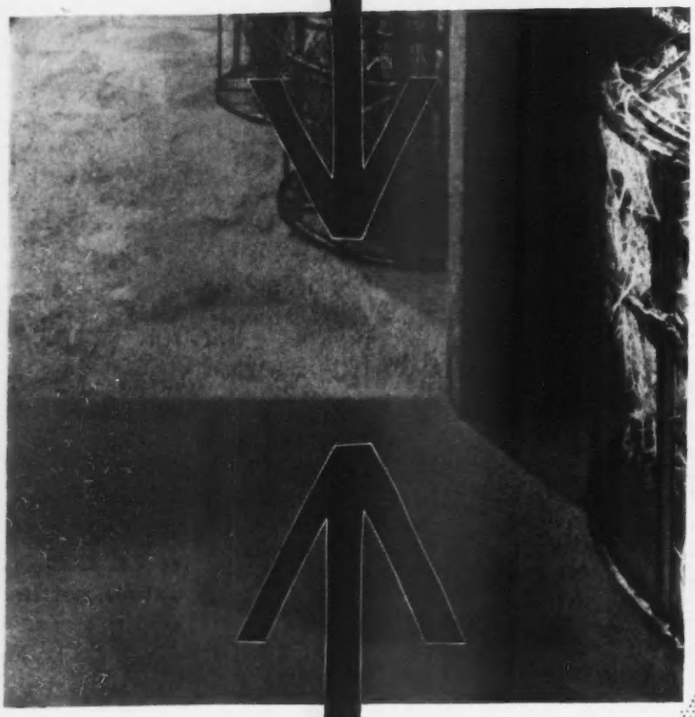

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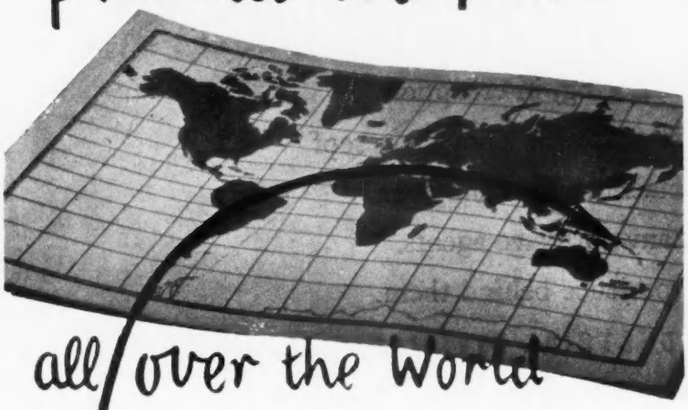

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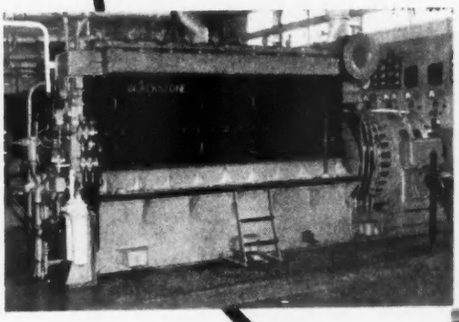

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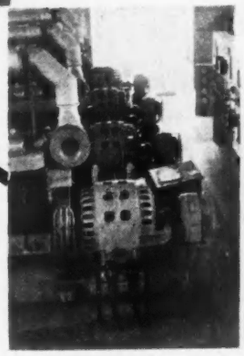

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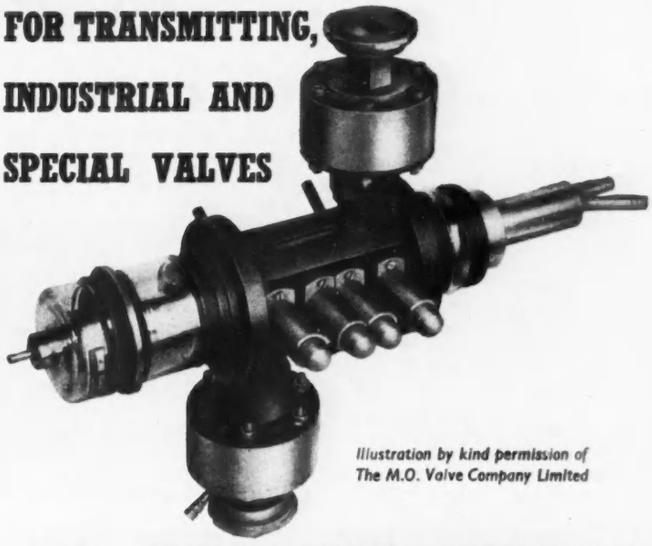

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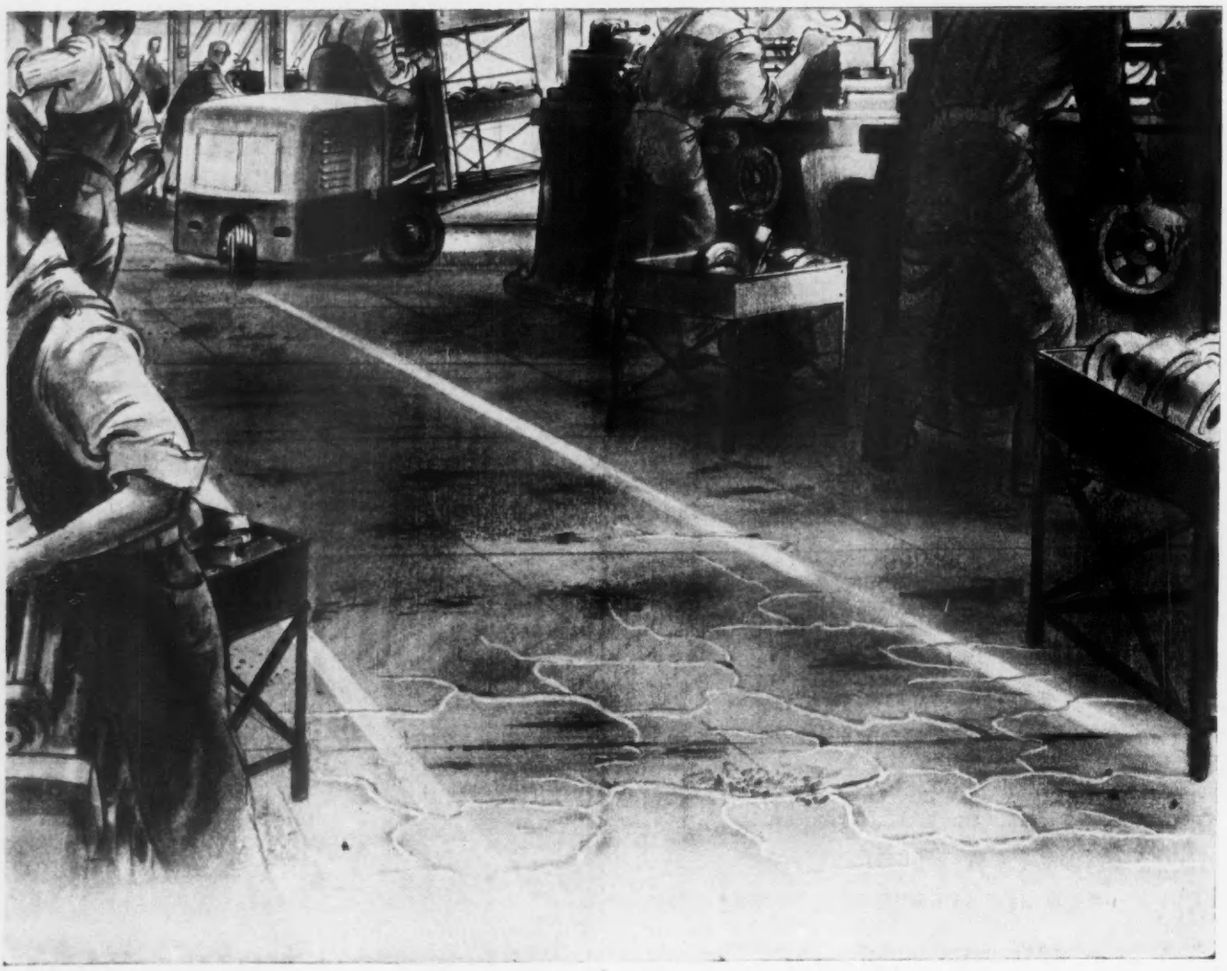

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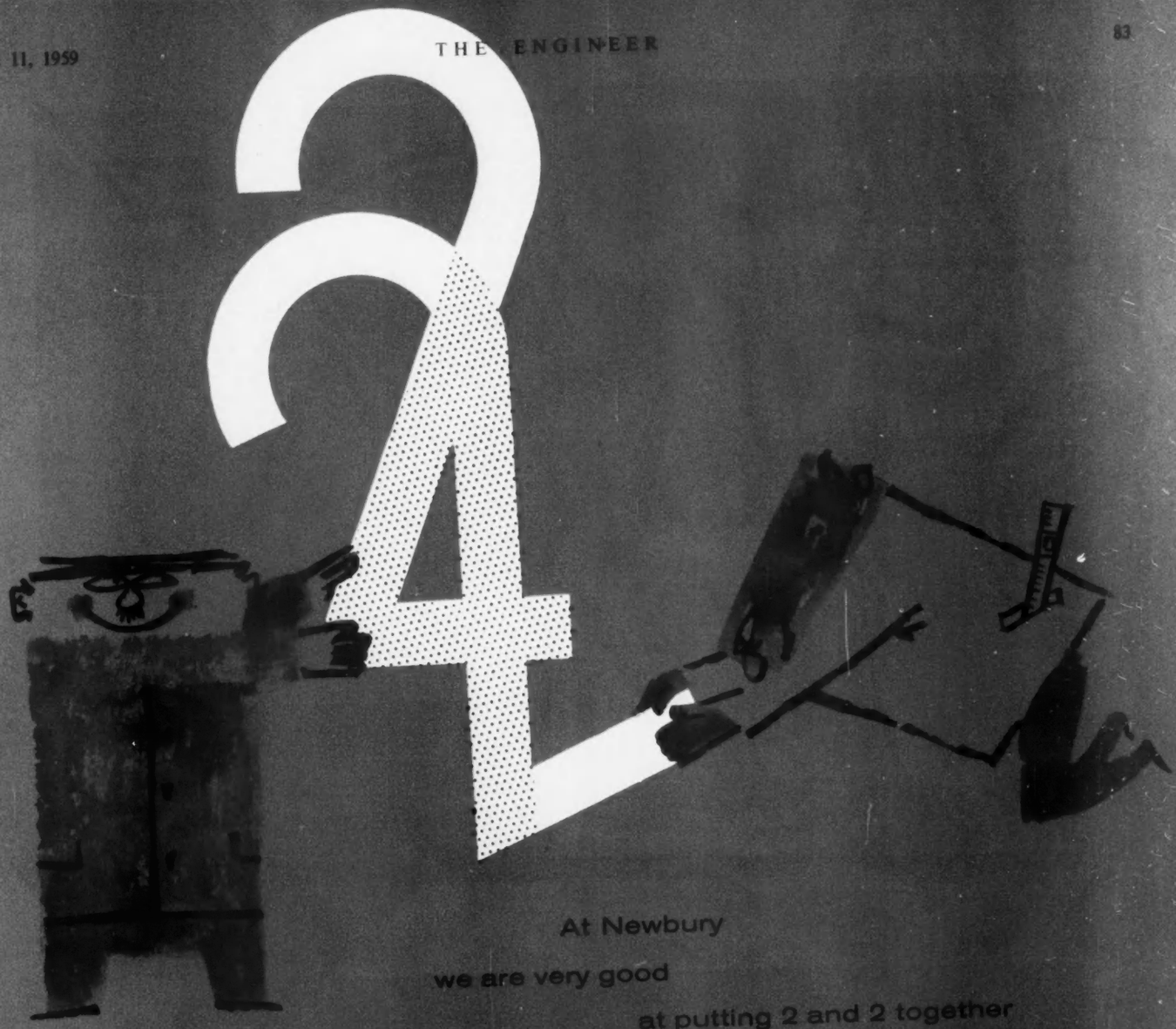

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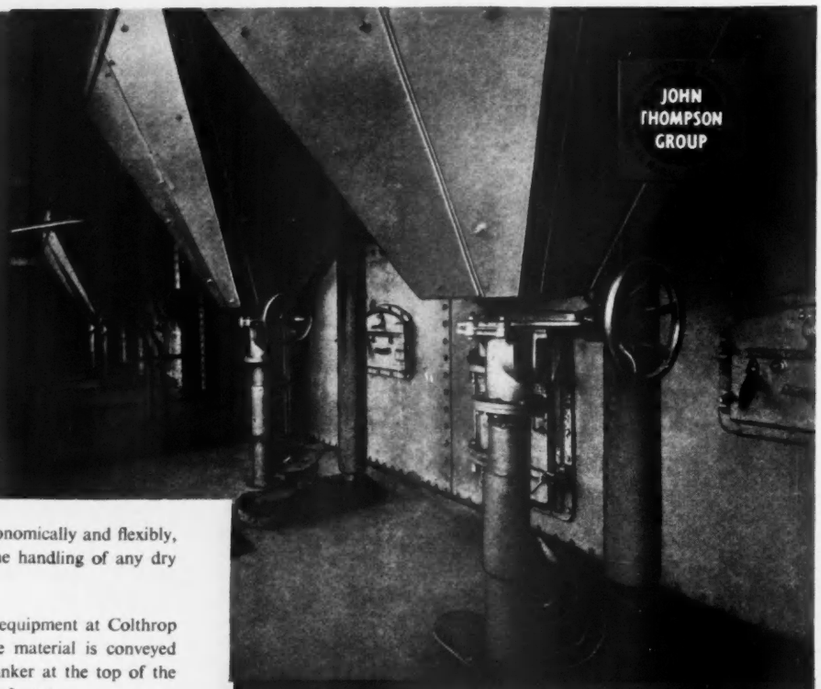

Pneumatic Handling can be applied economically and flexibly, even in smaller industrial plants, to the handling of any dry pulverised or granular materials.

In the illustration of John Thompson equipment at Colthrop Board and Paper Mills, Newbury, the material is conveyed from the four storage hoppers to a bunker at the top of the building, so that it can be re-fired to the furnaces.

Note the four material loading valves fitted directly to the storage hoppers; from these the conveying pipeline runs to a lower level for interconnection before rising to the container at the top of the building.

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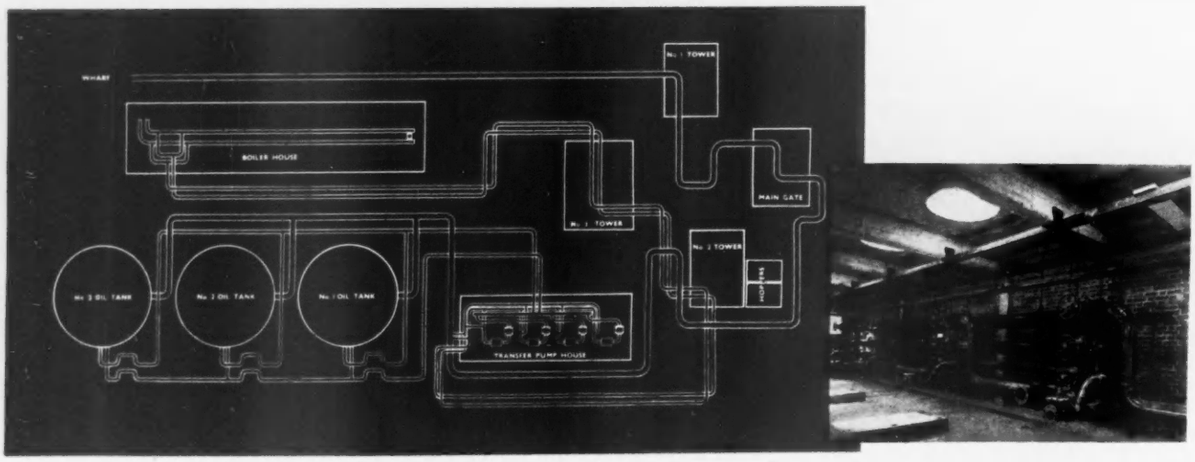

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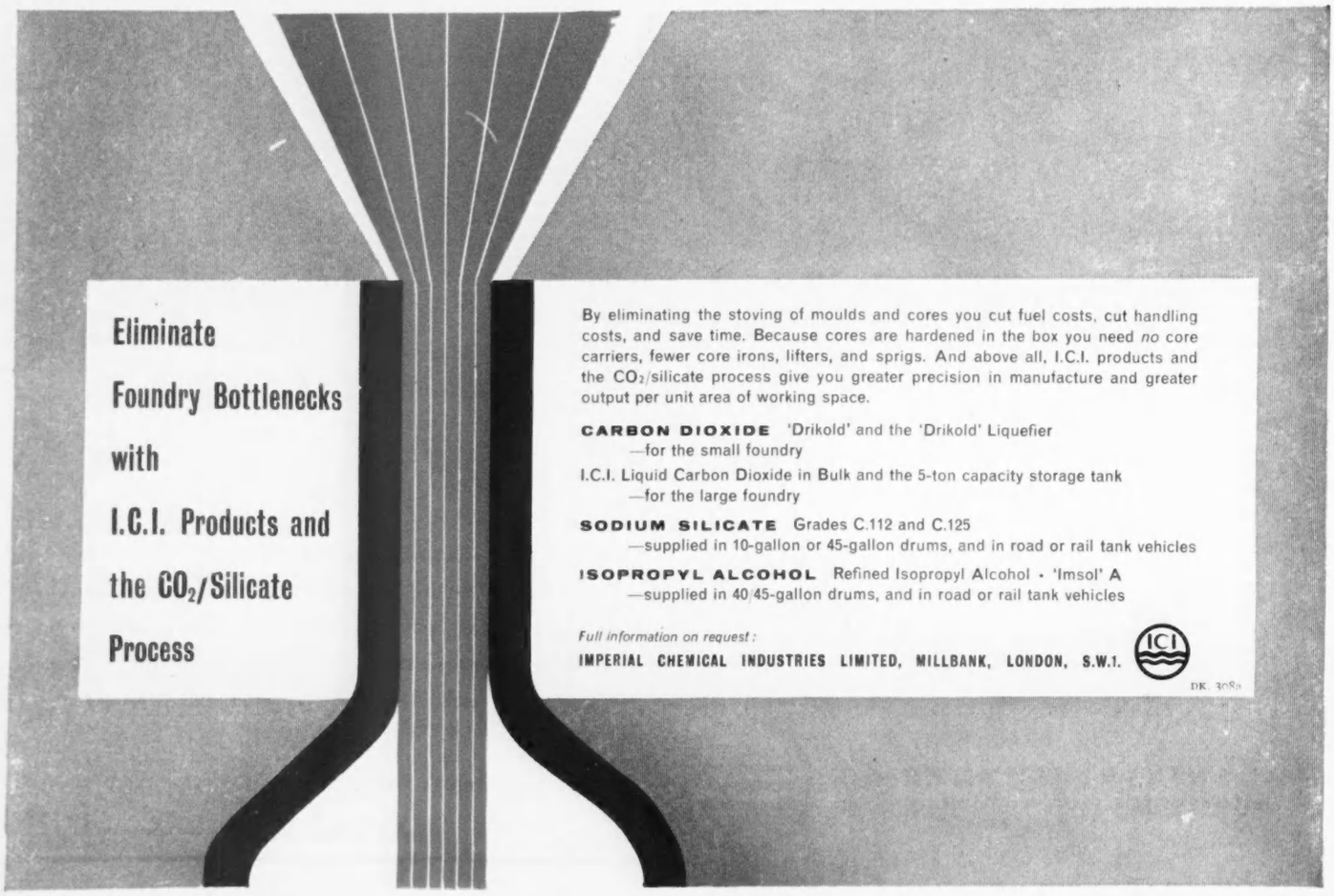

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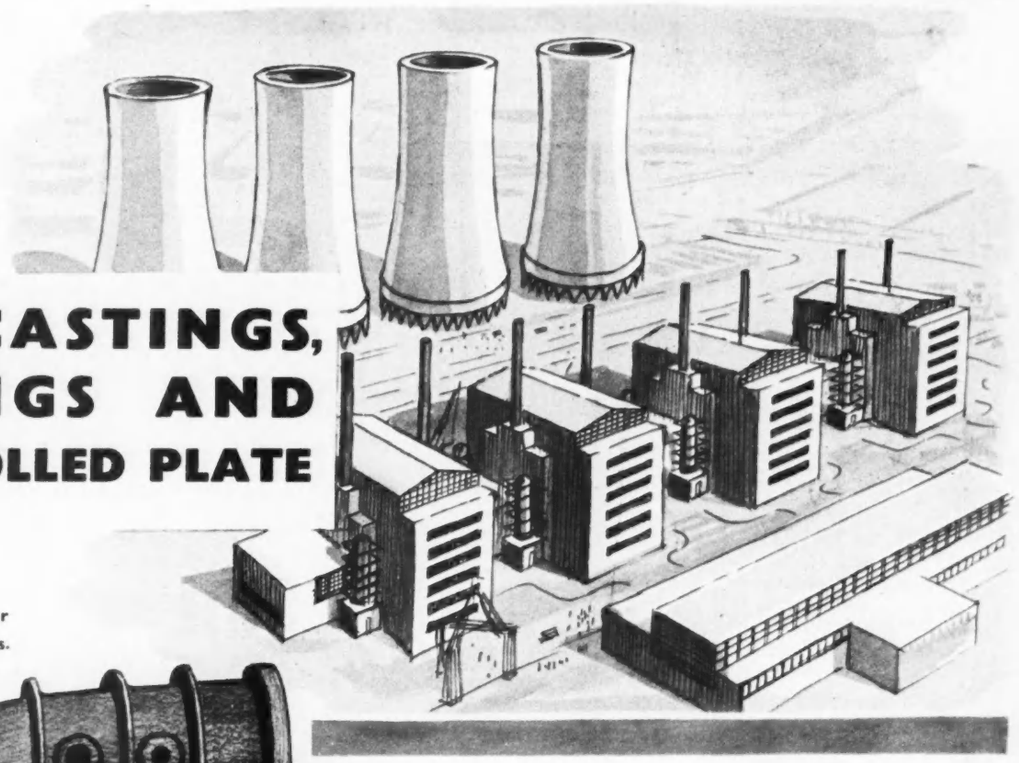
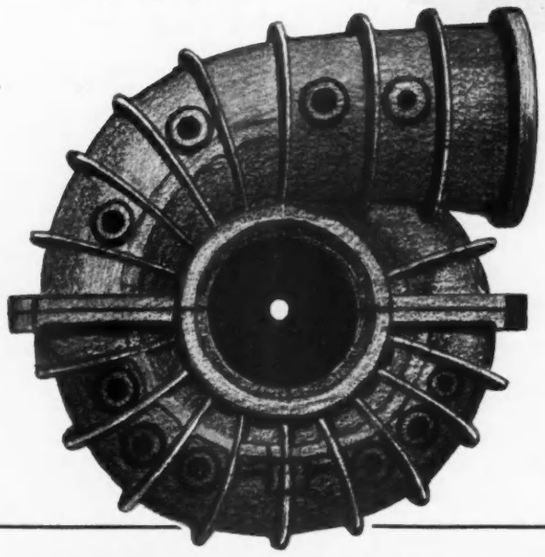
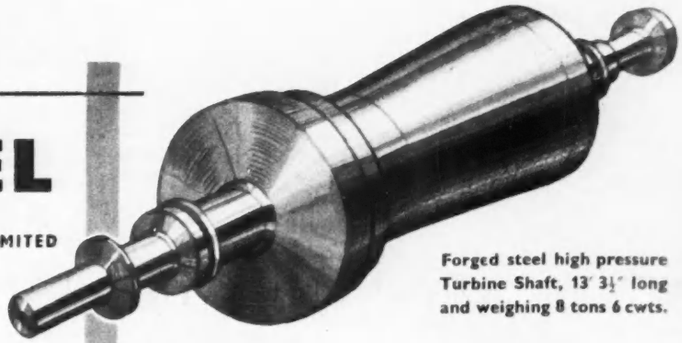


Cast steel Blower Casing, weight 31¾ tons.



for the Chapel Cross nuclear power station

supplied by the ESC Group of Companies include H.P. and L.P. forged steel Turbine Shafts and Alternator Rotors for four Turbo-Alternators, 4 forged steel Reinforcement Rings for the Inlet and Outlet Ducts for the Reactor Vessels, 5 pairs of cast steel Blower Casings for Gas Coolant Circulators, and 4,500 tons of heavy steel plate, 6″ thick, for Thermal Shields.



Forged steel high pressure Turbine Shaft, 13′ 3½″ long and weighing 8 tons 6 cwts.

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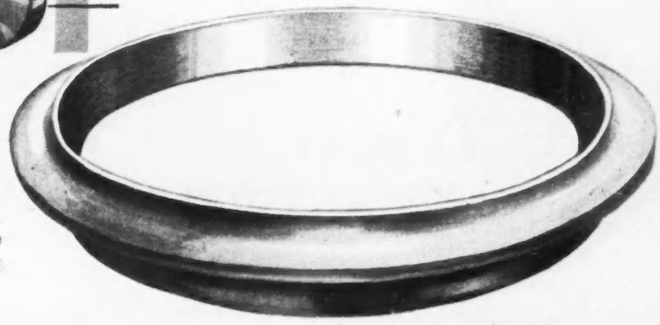
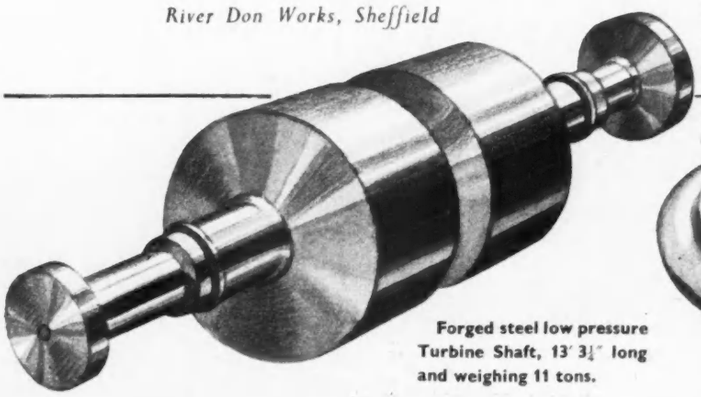
Forged steel Reinforcement Ring 13′ 8″ diameter for Inlet and Outlet Ducts for the Reactor Vessels.

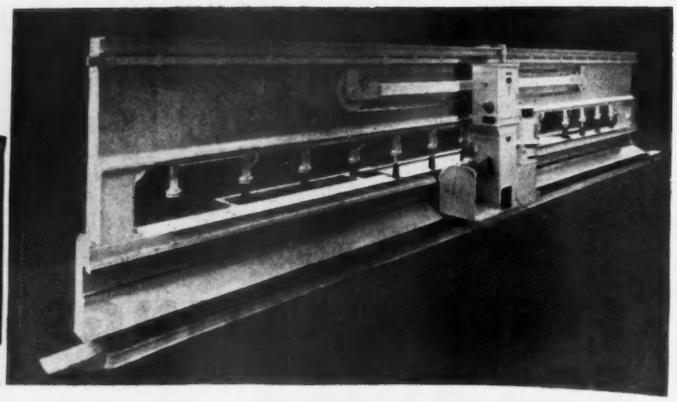




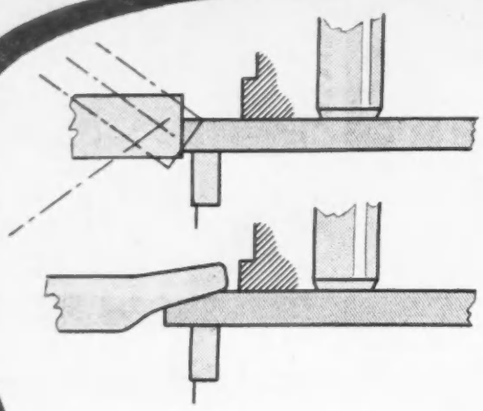
Forged steel low pressure Turbine Shaft, 13′ 3¼″ long and weighing 11 tons.

M

PLATE EDGE PLANING AND ROTARY SHEARING



JACK TYPE CLAMPING MACHINE



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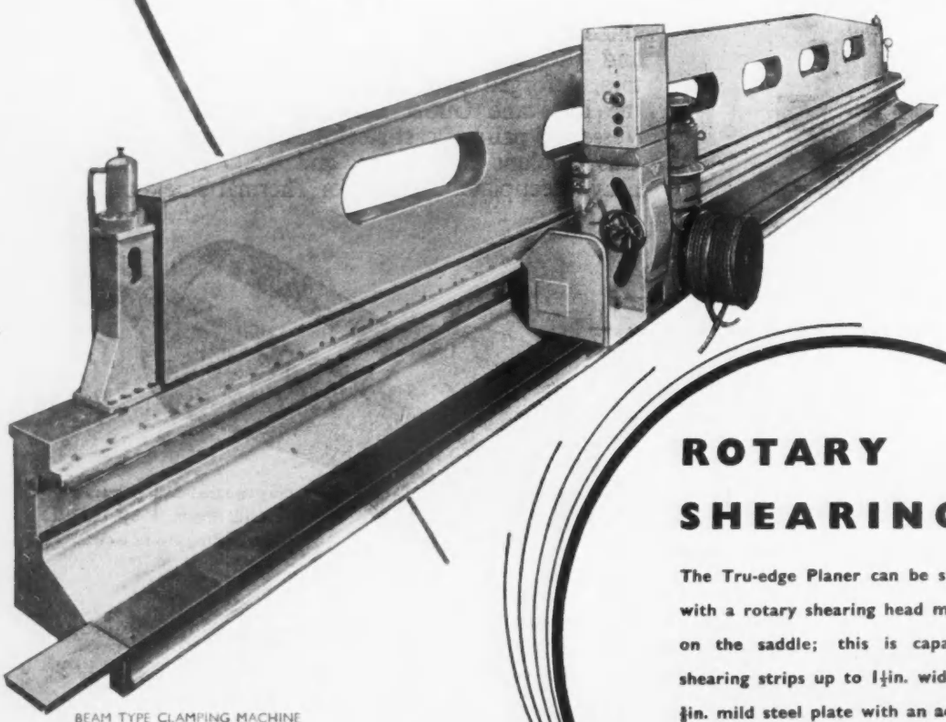
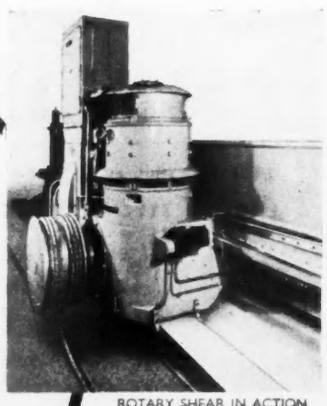
This planer, made in lengths of 25, 30, 35 and 40 feet, handles plates up to 2in. thick with speed and accuracy, and where thicker plates, or bundles of plates require edge planing we can provide a motorised tool box with a vertical rise of 6in. for progressive planing. Profile tools can be used in either case, or swivelling action can be provided for planing top and bottom bevels up to 35 deg. above or below the centre line. A special planing tool is available for cutting long bevels. In design and construction the Tru-edge Planer is highly modern in every respect and it will provide many years of excellent service. We will be pleased to supply technical information.



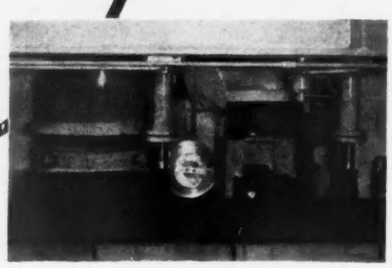
BEAM TYPE CLAMPING MACHINE

ROTARY SHEARING

The Tru-edge Planer can be supplied with a rotary shearing head mounted on the saddle; this is capable of shearing strips up to 1¼in. wide from ⅜in. mild steel plate with an accuracy of 0·01in. in 40 feet. Its operation is about forty times faster than gas cutting, and less expensive.



ROTARY SHEAR IN ACTION



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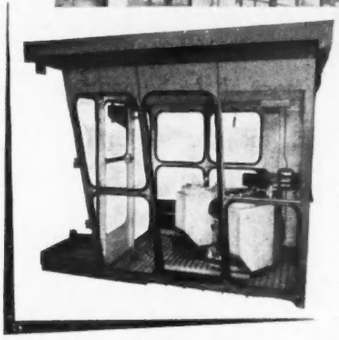

★ *a view of the cab showing the seat control unit.*

The Adamson 50/10 ton crane is the third of a series of new design supplied to Richard Thomas & Baldwins Limited, Ebbw Vale Section. Features of the crane include monolithic construction of the crab and the elimination of castings by mild steel fabrication of the hoist barrel and bottom block. The cab is of particular interest as it incorporates the most modern type of seat unit ensuring maximum vision and ease of control. Joseph Adamson electric overhead travelling cranes can be supplied to all specifications including cranes suited to the most exacting 24 hours-a-day process work.

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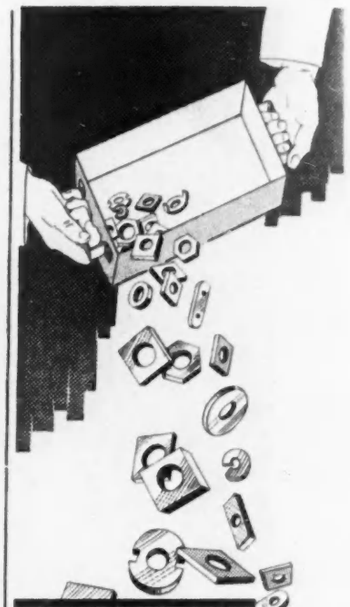

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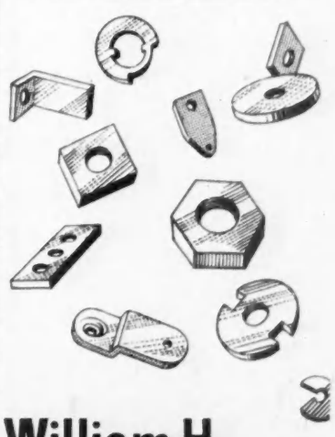

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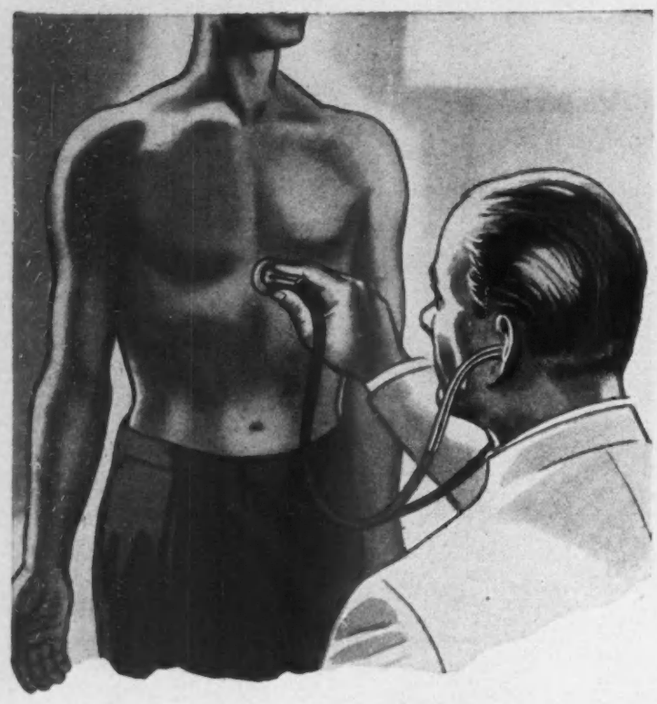

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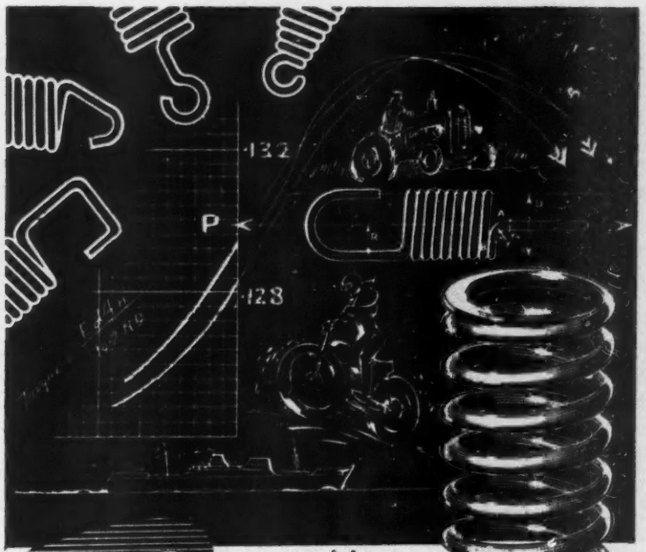

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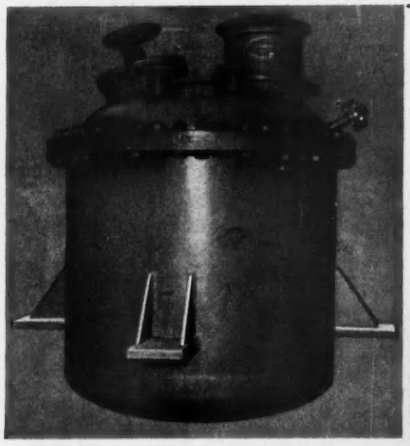

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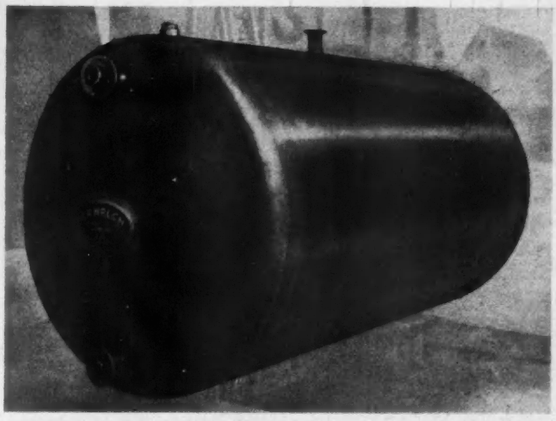

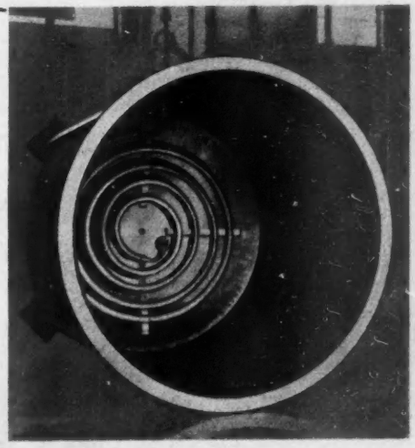

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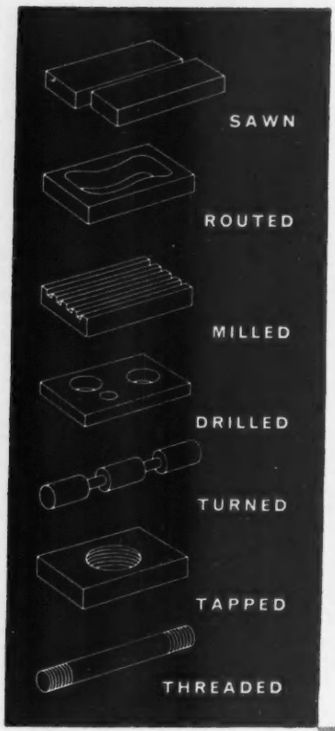

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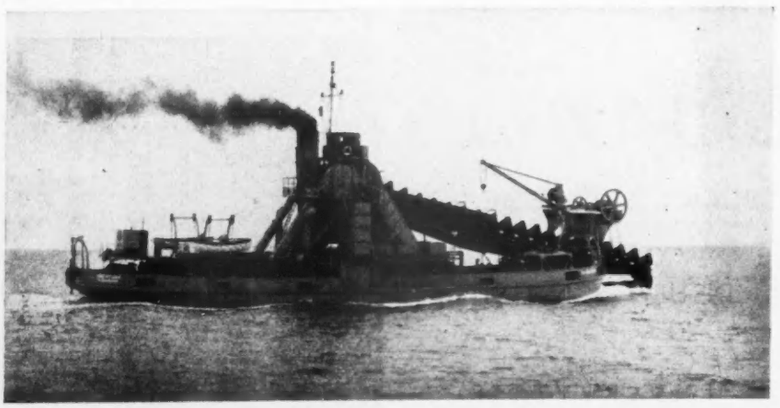

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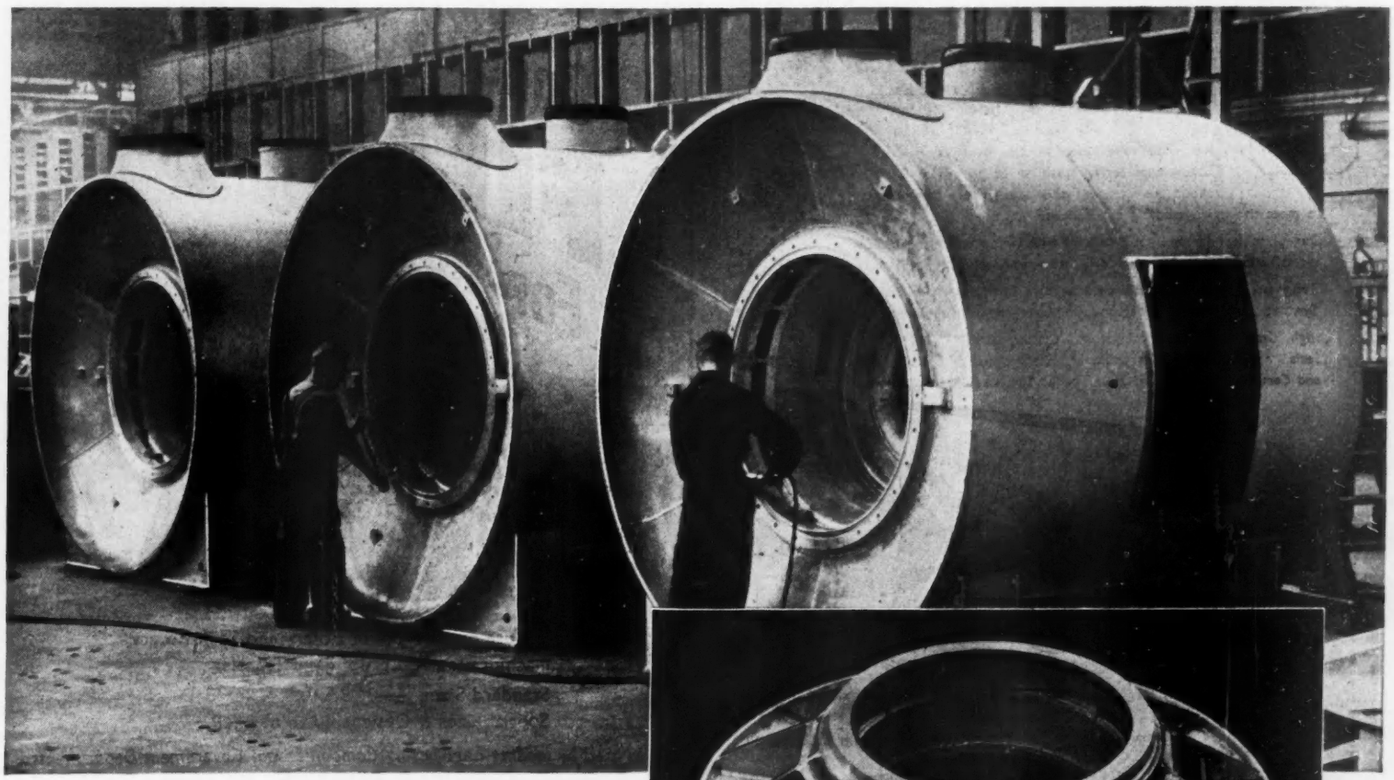

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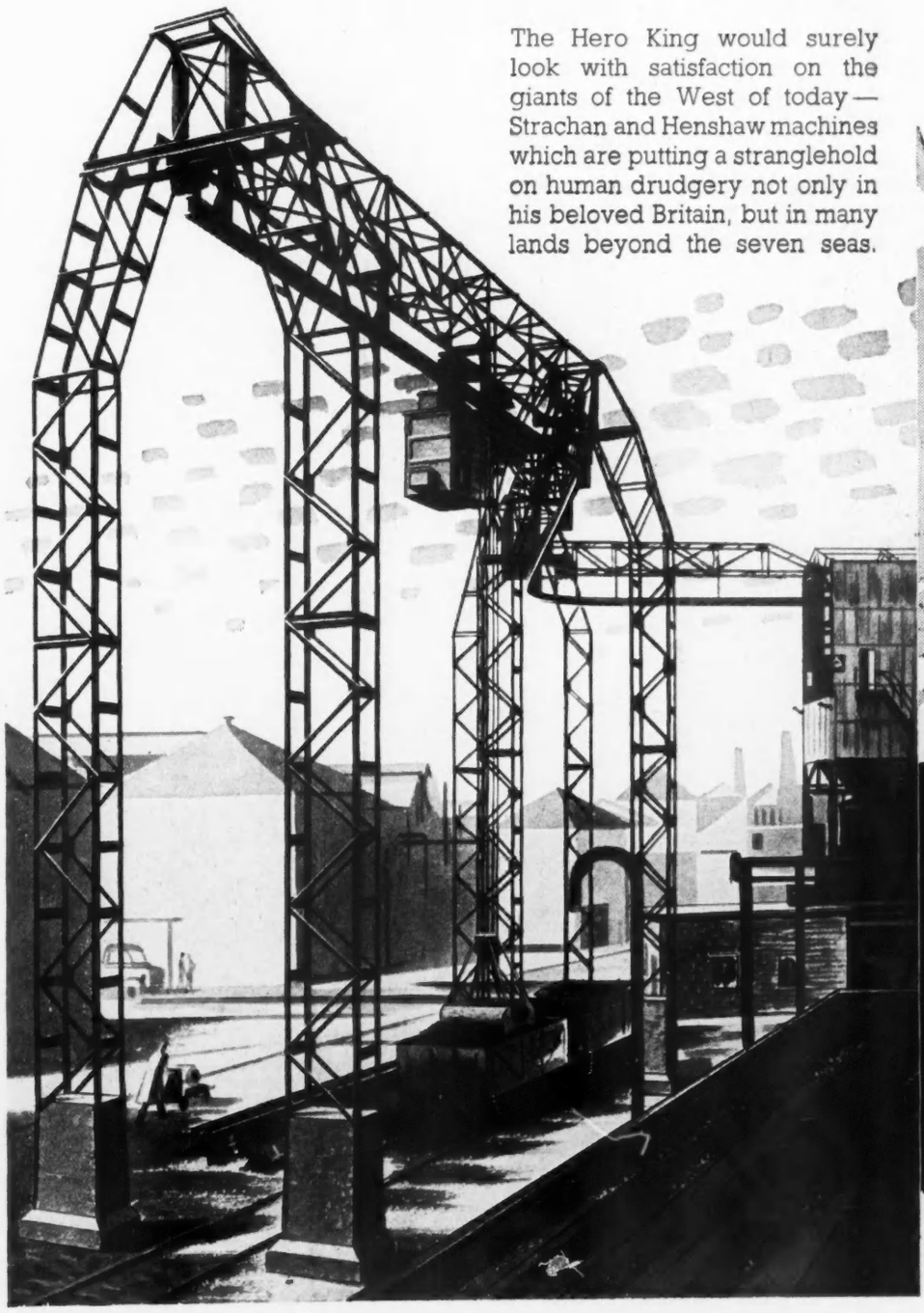

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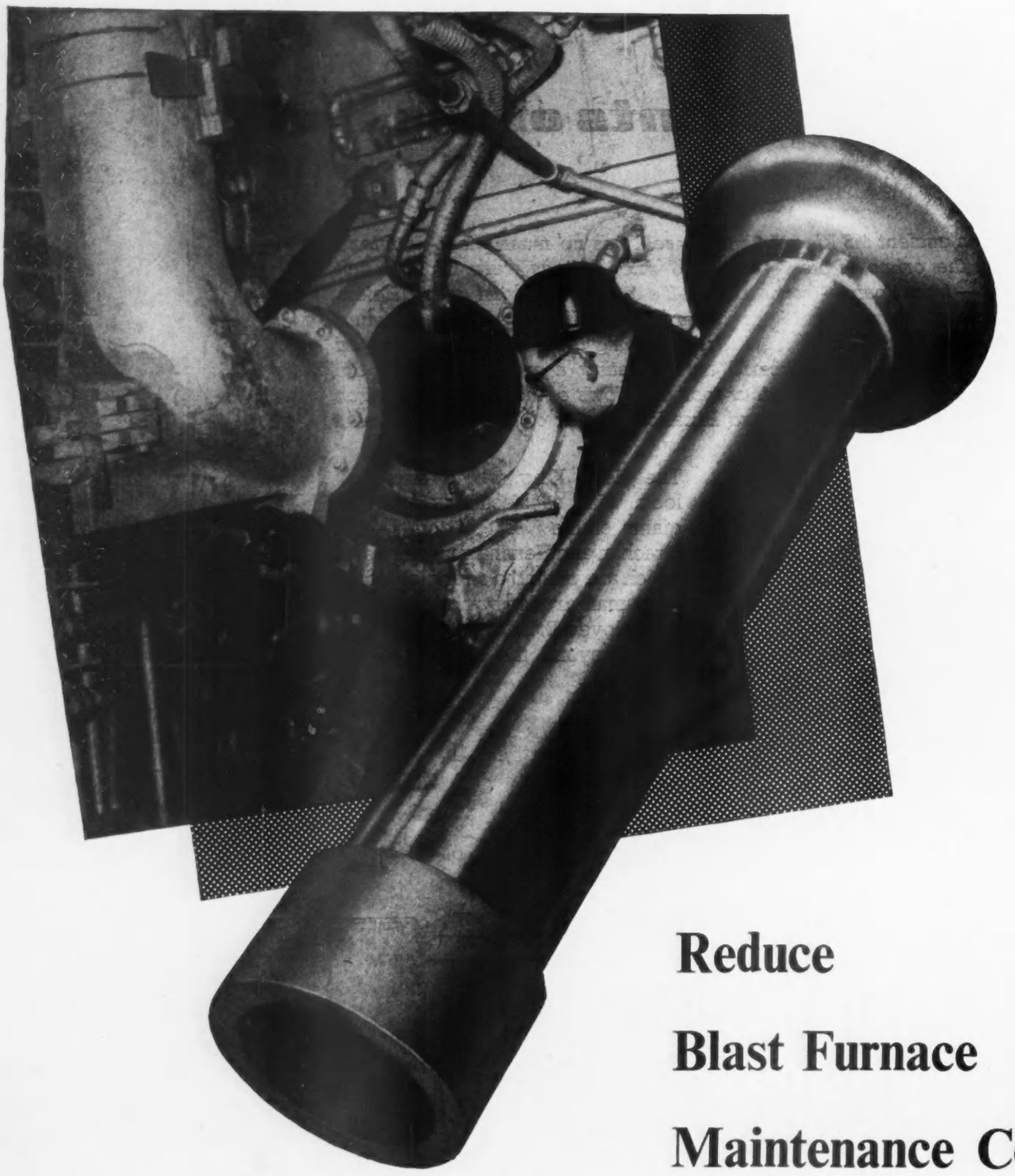

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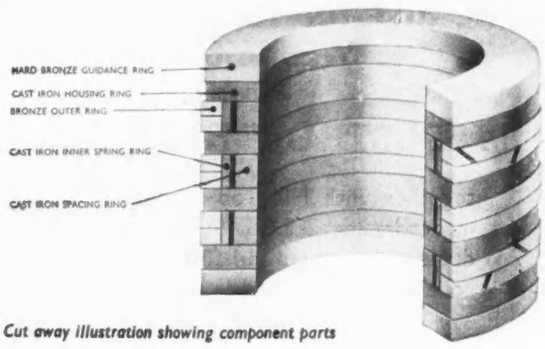

Cut away illustration showing component parts

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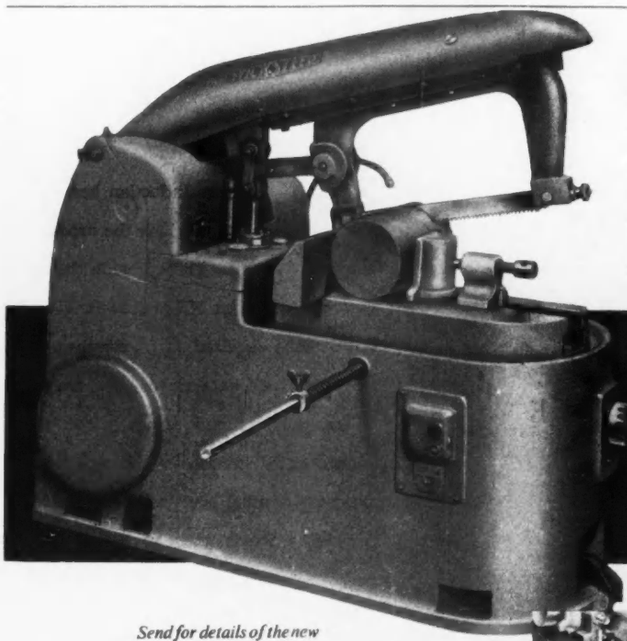

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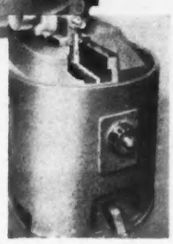

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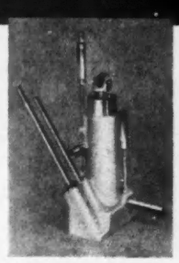

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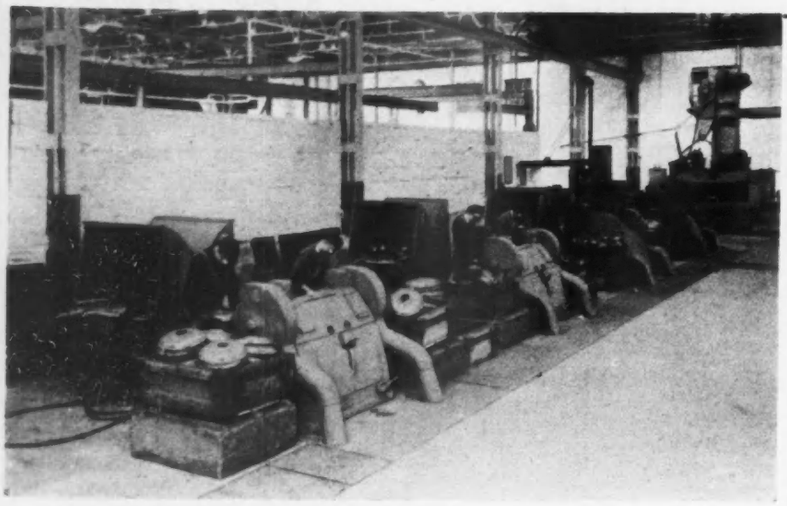

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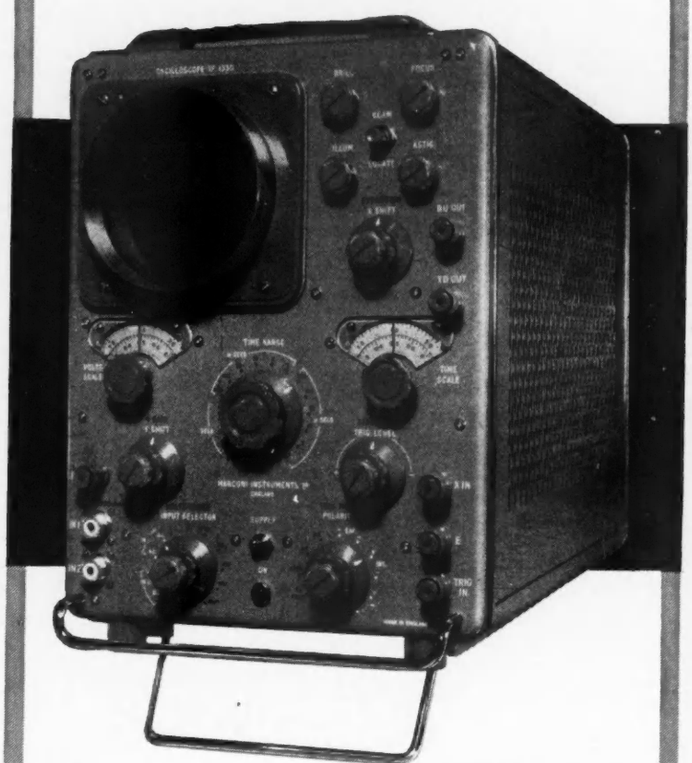

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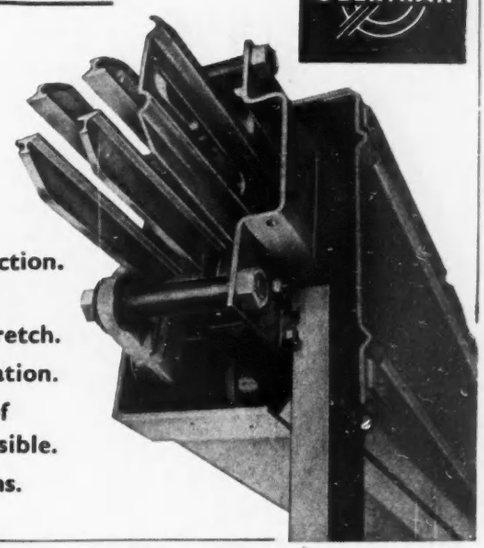

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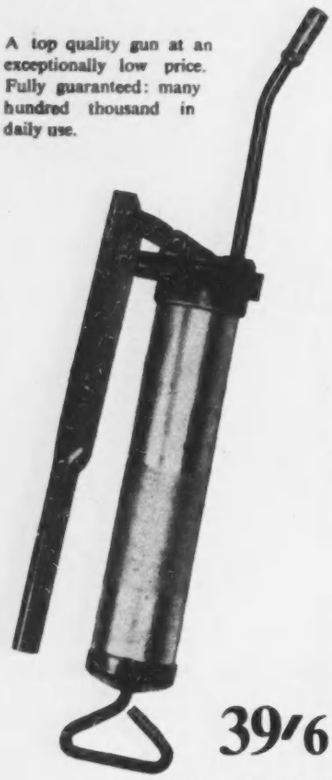

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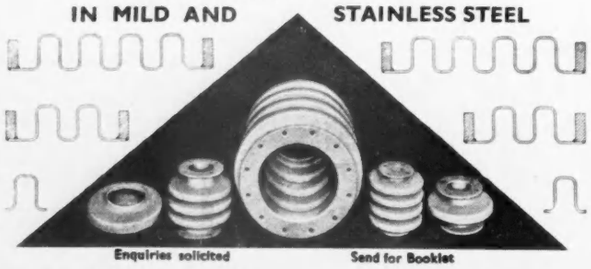

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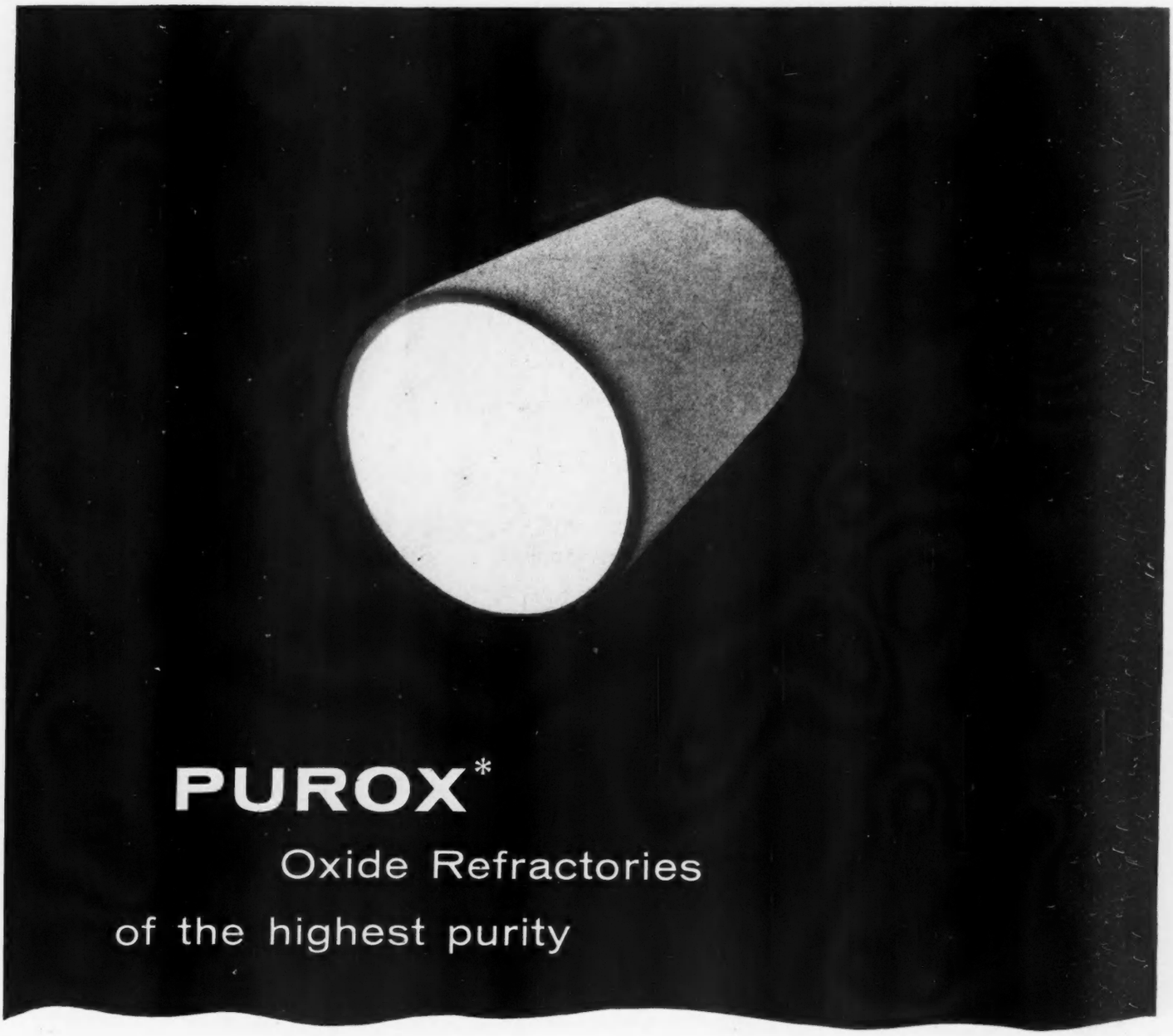

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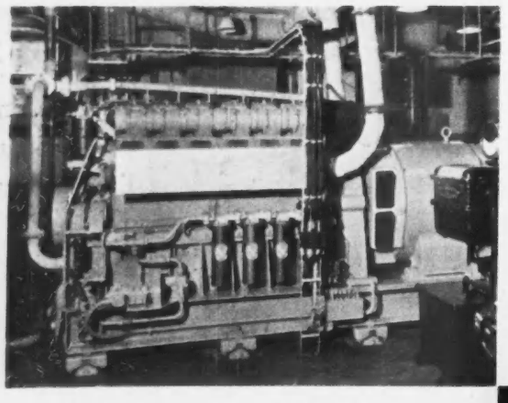

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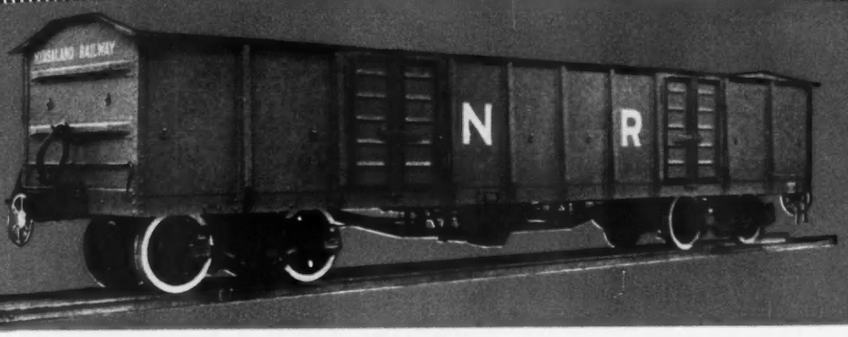

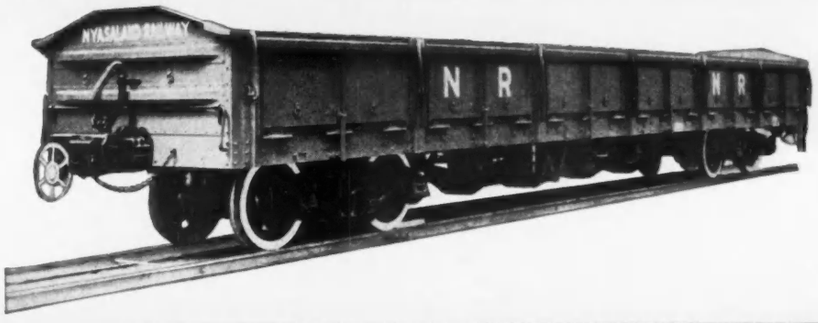

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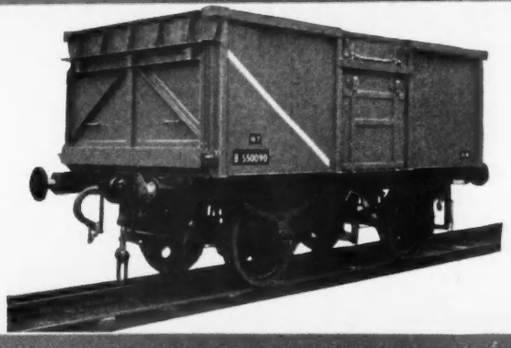

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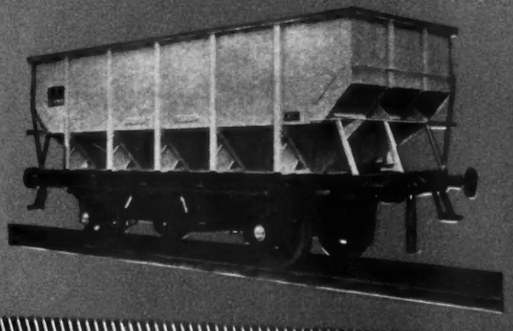

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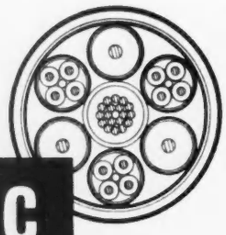

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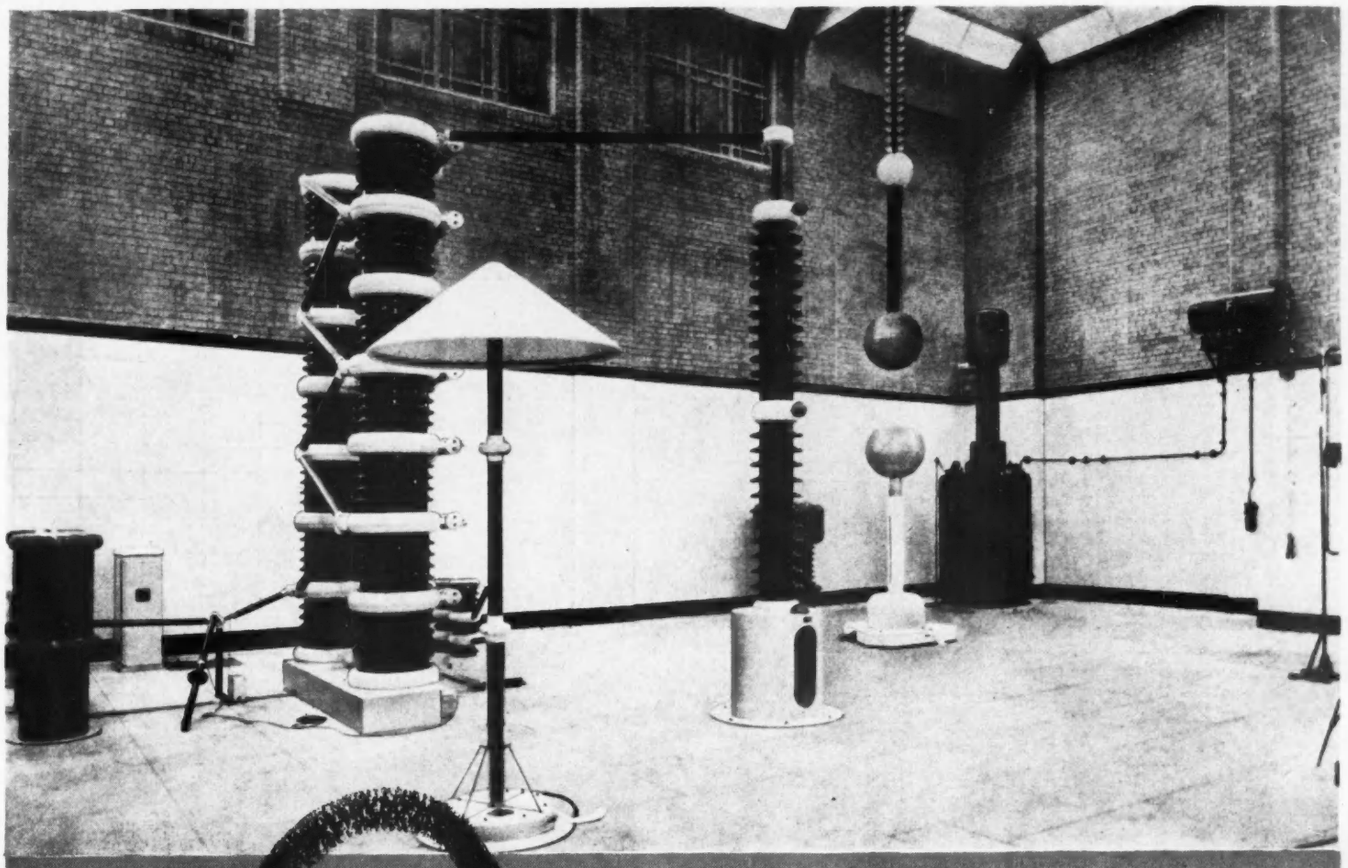

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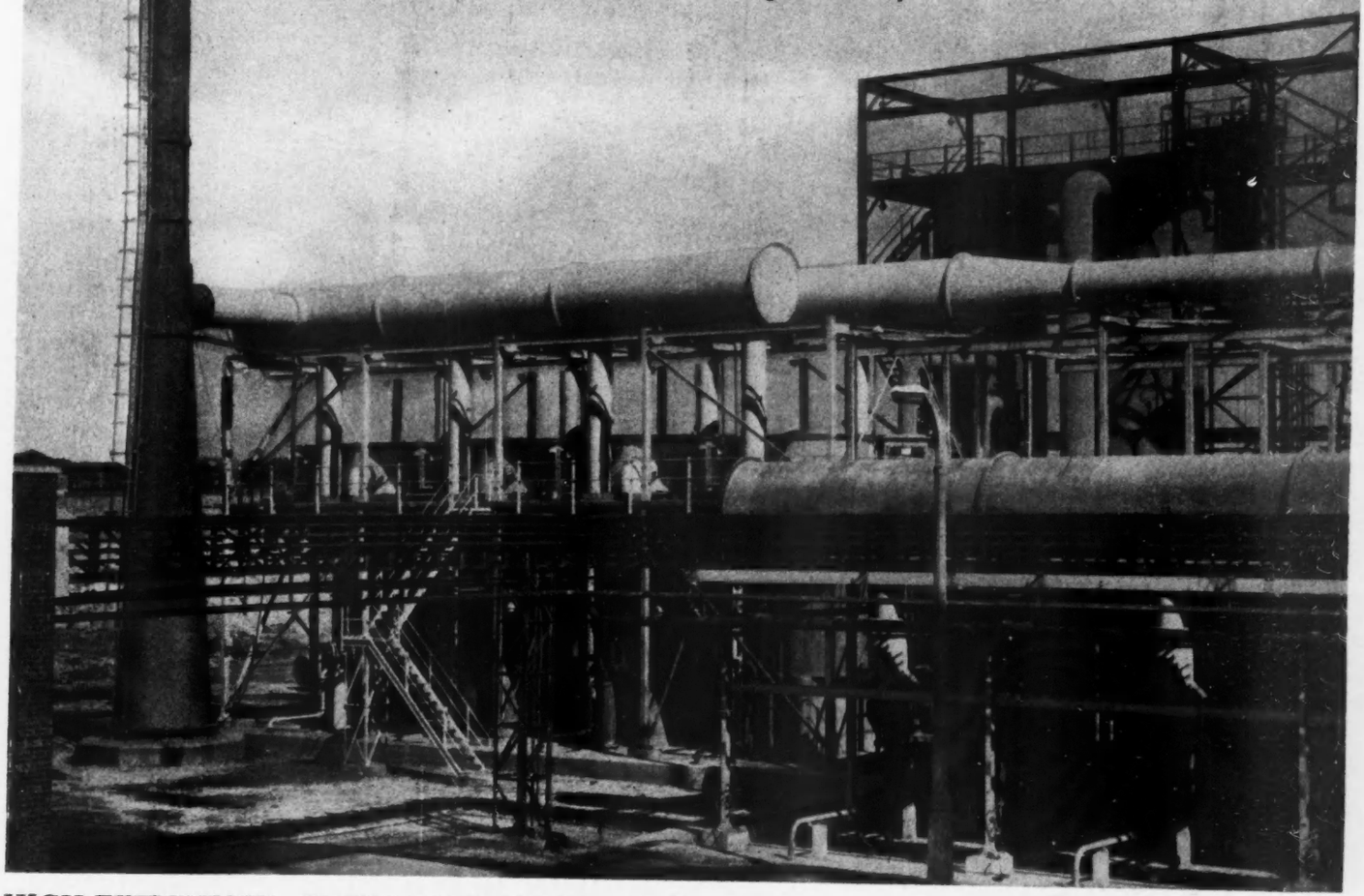

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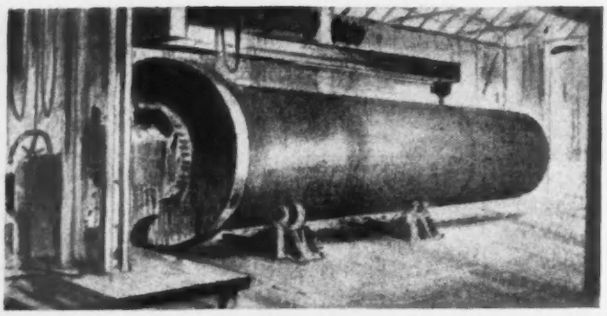

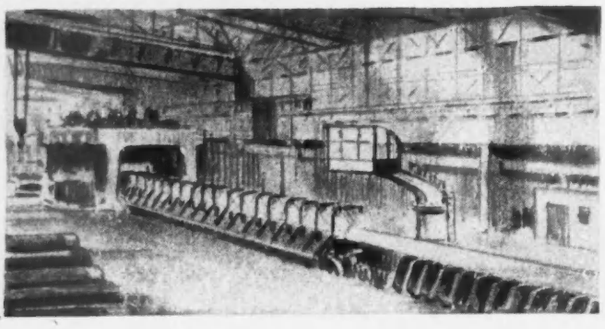

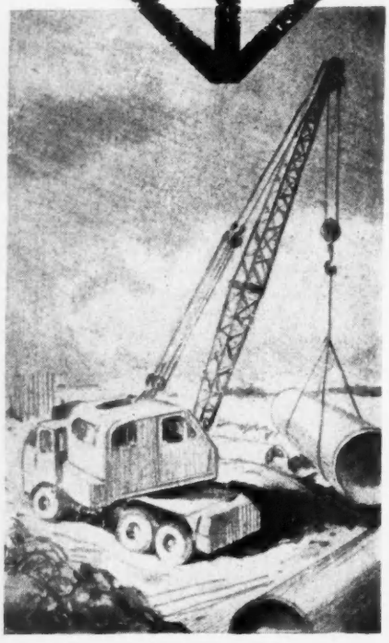

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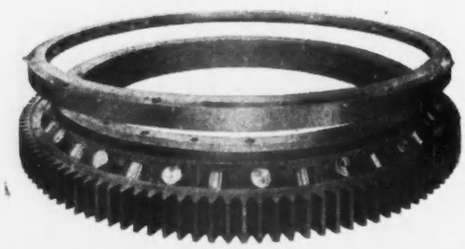
Evolved, perfected and manufactured in Great Britain in collaboration with British Timken Limited.

The Priestman Cross-Roll Bearing consists of four separately machined rings. When bolted together in pairs the roller paths form a diamond pattern race section.

The Timken tapered rollers, spaced on the pitch circle by pressed steel cages, alternately contact opposing race surfaces of the outer and inner rings. The crossing of the roller axes in combination with the inclination of the roller paths is the feature that enables the Bearing to resist loads in all directions.

Priestman Cross-Roll Bearings are pre-loaded, pre-lubricated, and sealed self-locating assemblies, requiring no adjustment and little maintenance beyond the periodical replenishment of grease in the labyrinth which supplements the special synthetic rubber cruciform seal, excluding all foreign matter.



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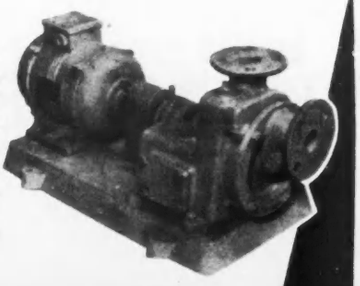

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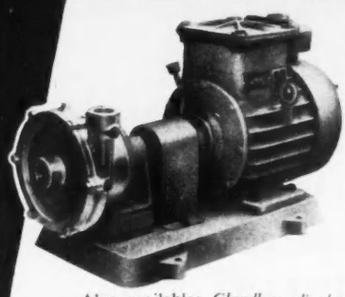

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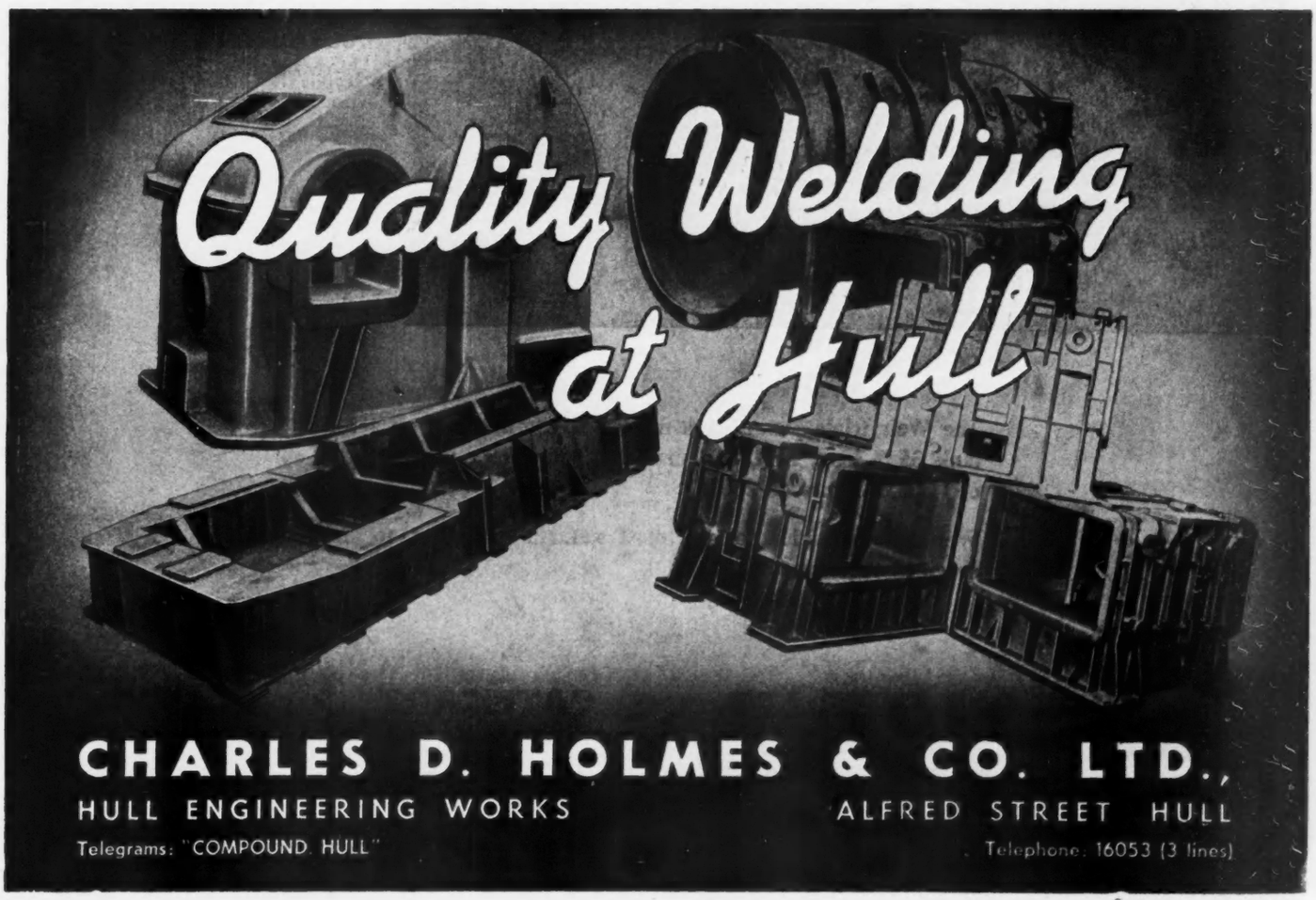

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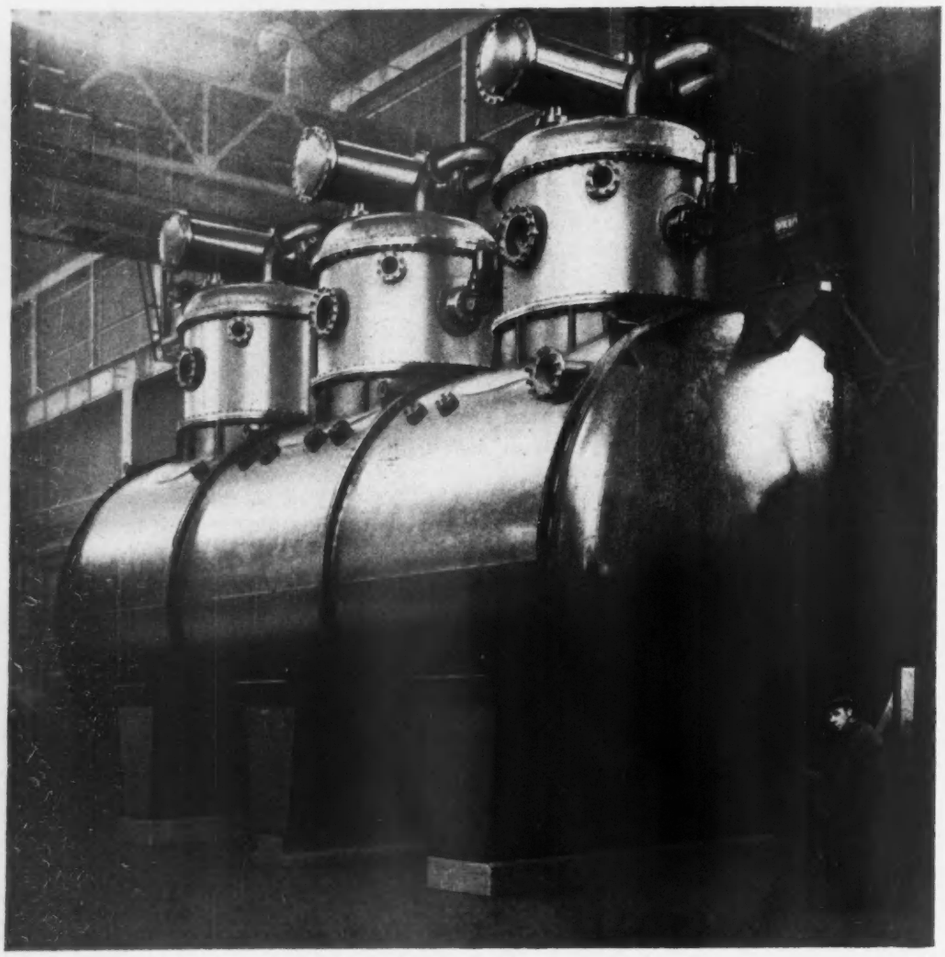

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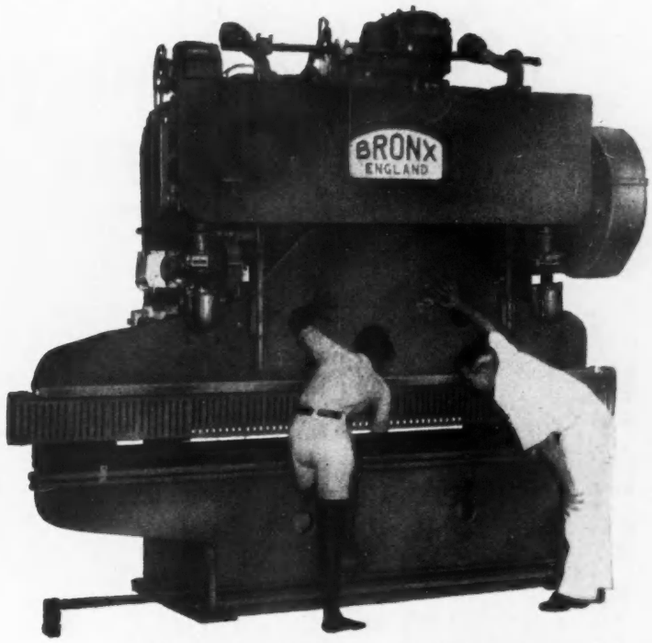

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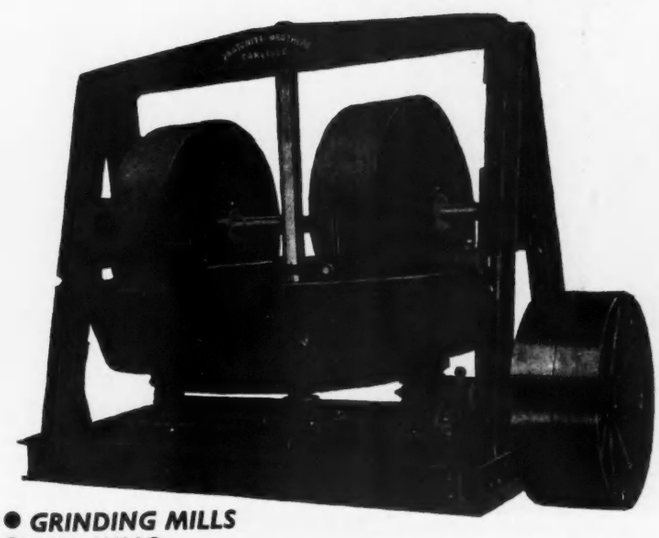

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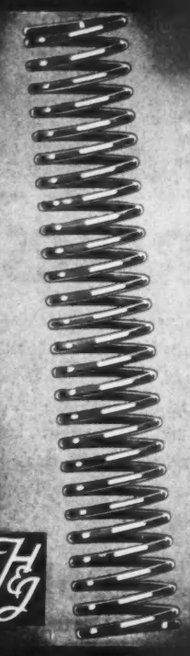

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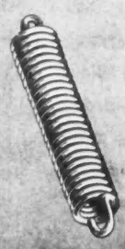

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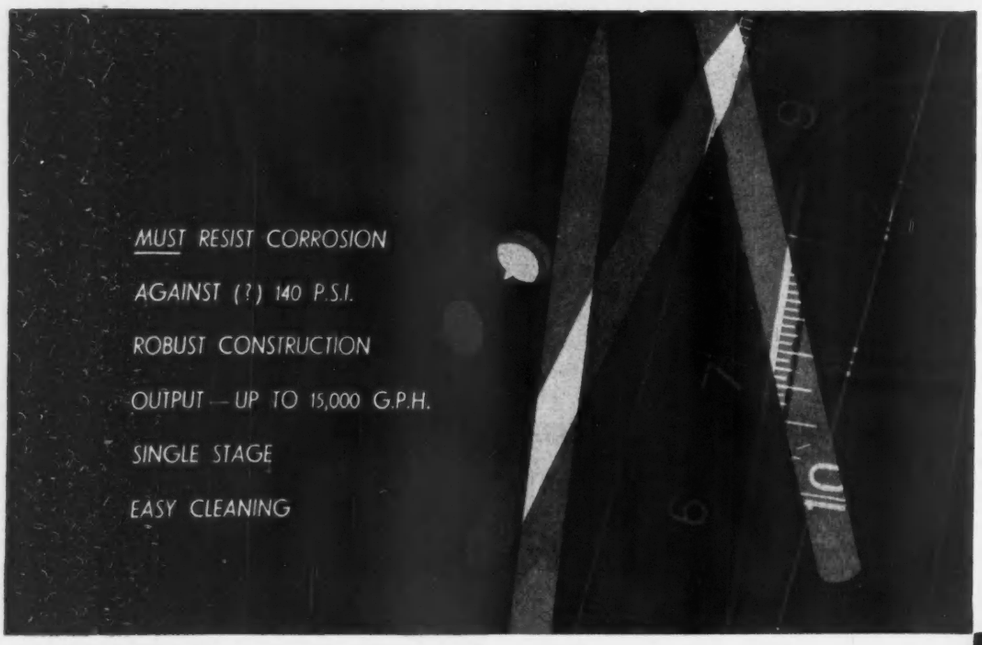

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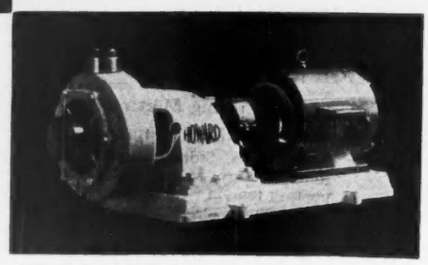

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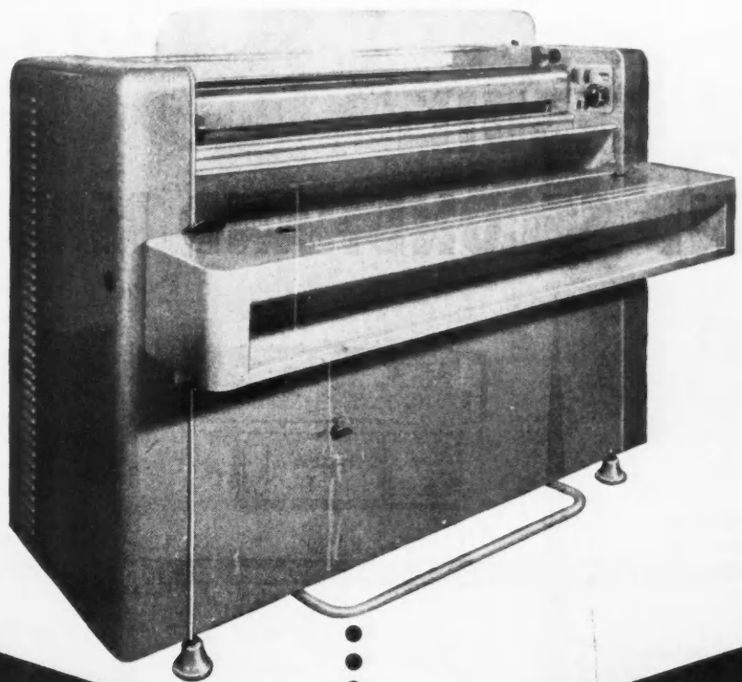

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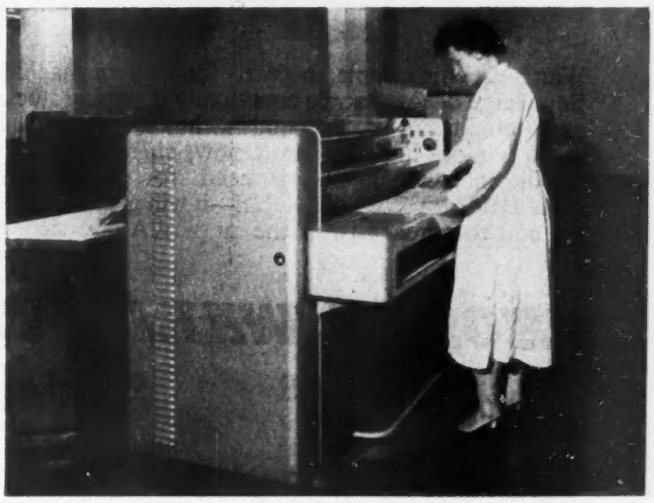

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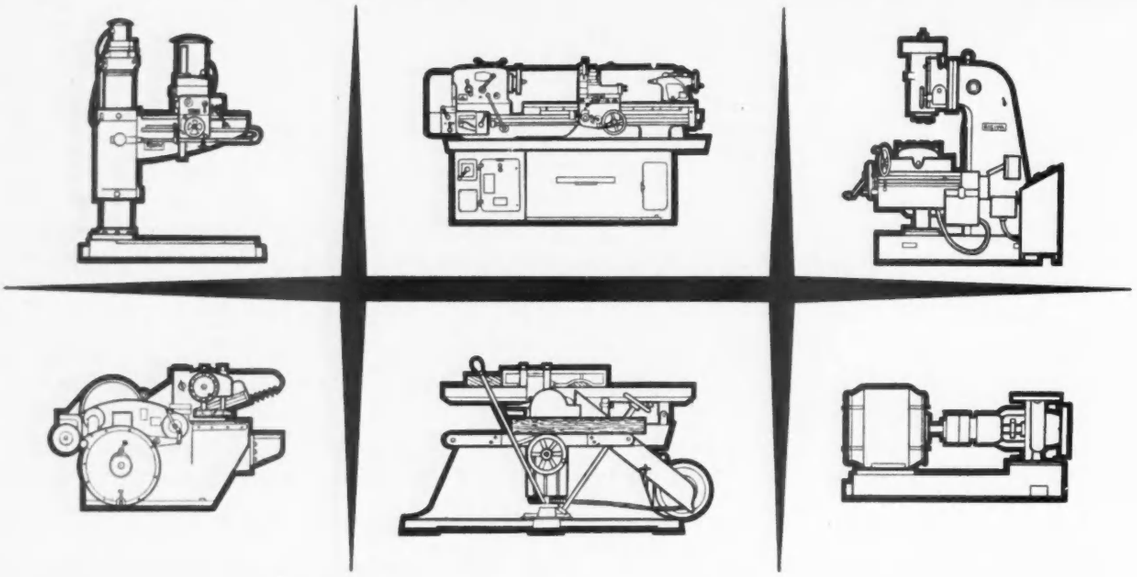

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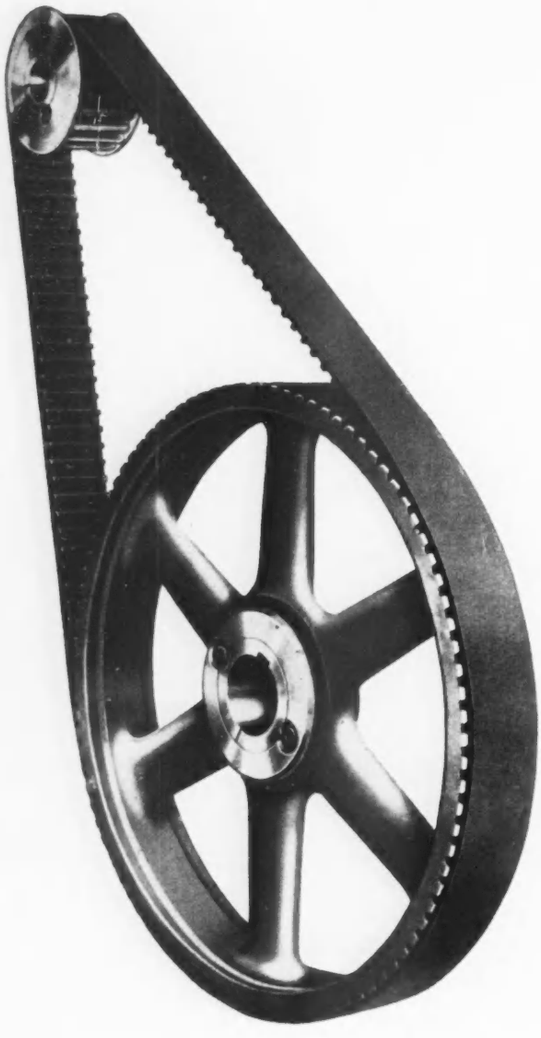

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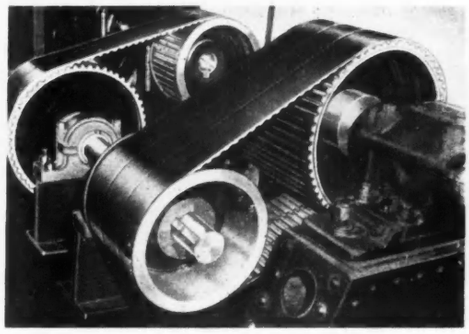
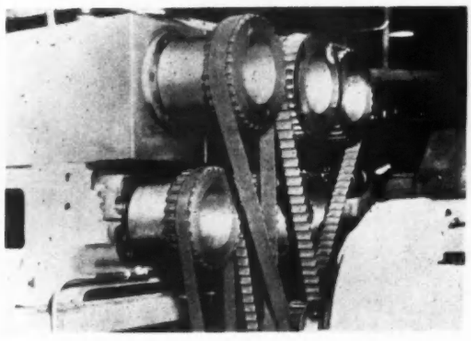


PowerGrip Timing Belts as an increasing gear on a dredge pump.



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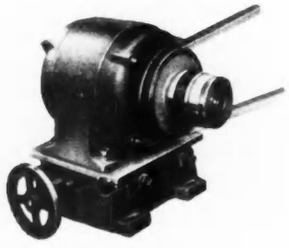

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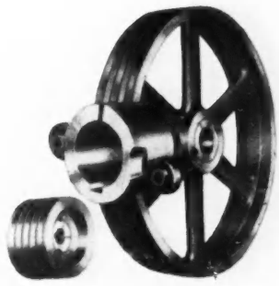

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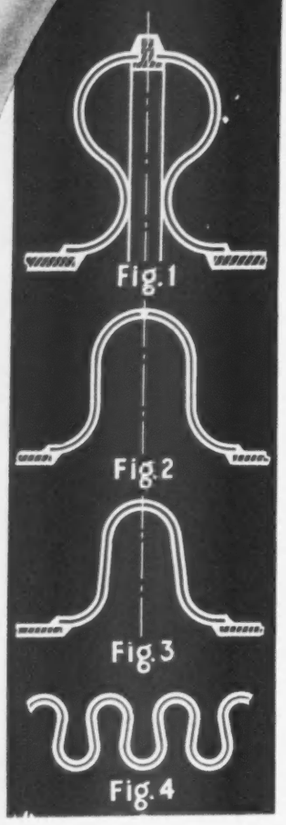

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Fig. 1 Bellows expansion fitting formed by "S" pressings. Any multiple of bellows up to five in number can be supplied in sizes from 3 in. to 84 in. bore.

Fig. 2 An alternative bellows profile particularly suitable for transverse movement. The height of the bellows is varied to suit individual pressures and working conditions.

Fig. 3 A bellows profile which may be formed by deep pressing. This type of expansion fitting is built up in three or more sections with longitudinal welds.

Fig. 4 One of the profiles available for the Aiton "A" type expansion fitting. This unit is made by a special process which obviates the need for circumferential welding at the crown of, and between, convolutions.

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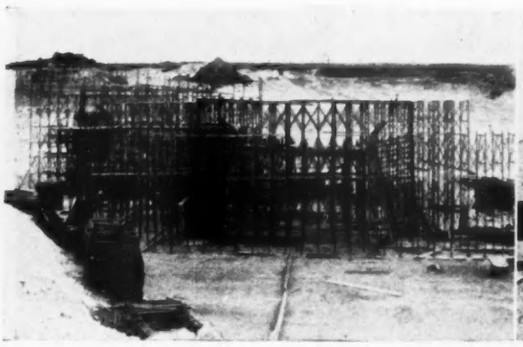
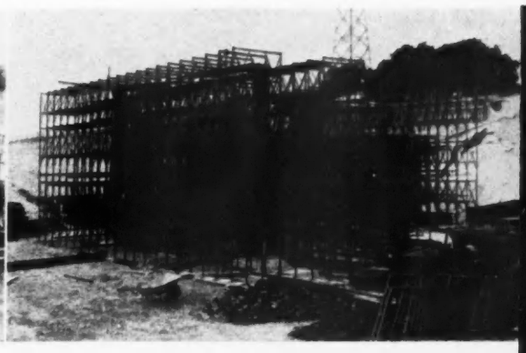
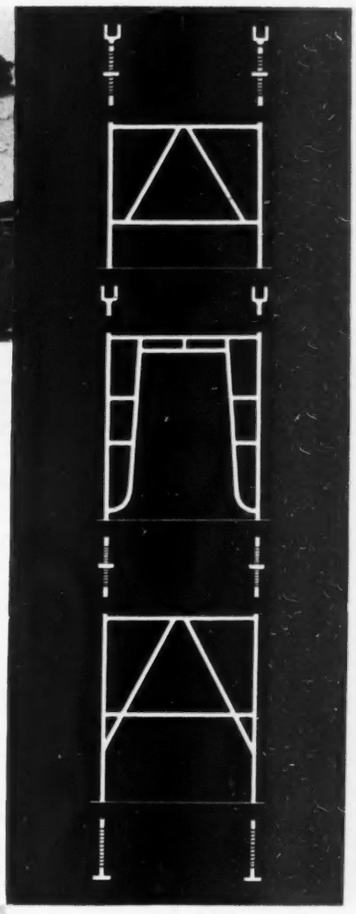




The photographs show Sterling Safway Scaffolding in use at No. 6 Bridge on St. Albans Bye-Pass built by Messrs. TARMAC Ltd.

The pre-fabricated unit frames are light to handle, strong and rigid in use and are available in various heights to a standard width of 5 ft., 2 ft. 6in. x 2 ft. allowing access through the scaffolding where required. Safway can be bought, hired or supplied on contract inclusive of labour and transport.



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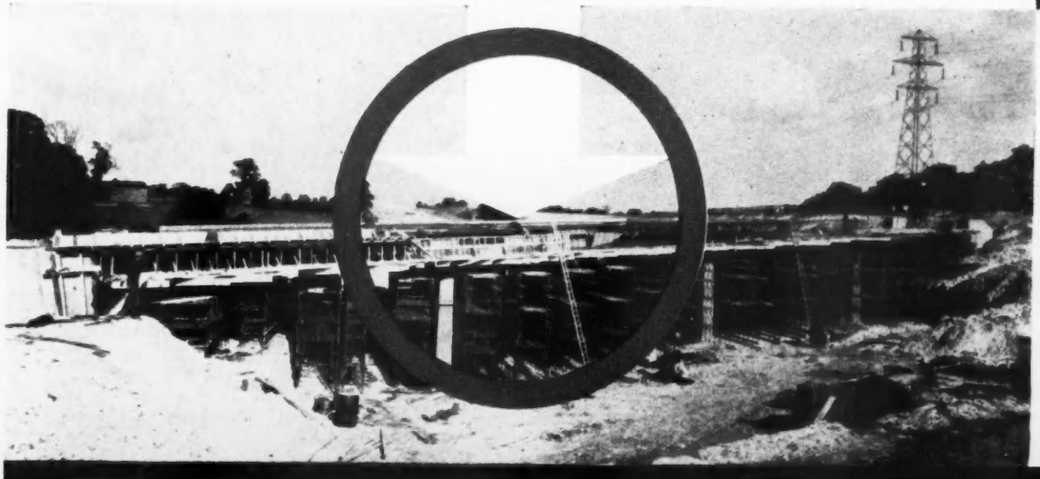
STERLING SAFWAY



Large load-bearing structures easily and quickly built from standard Sterling Safway Unit Frame Scaffolding

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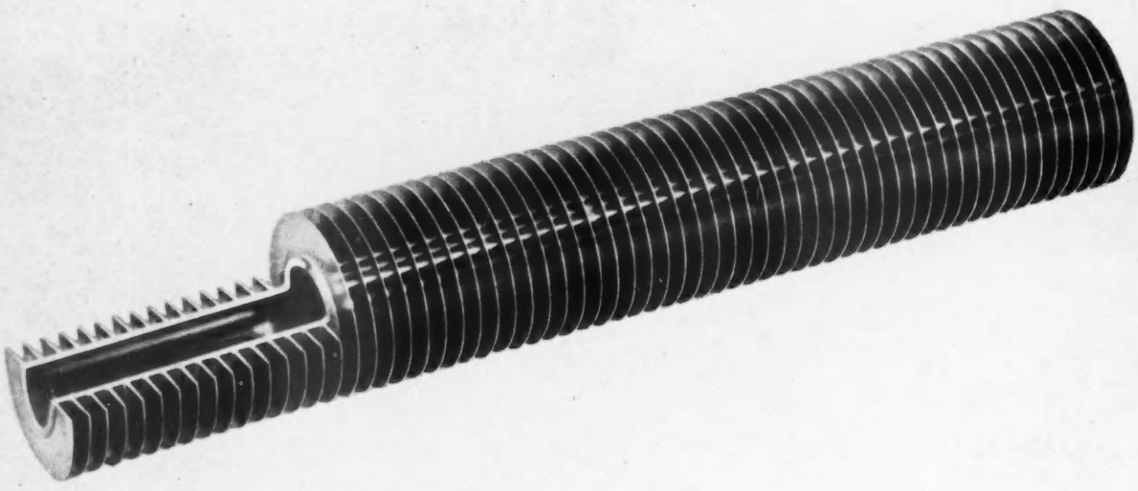

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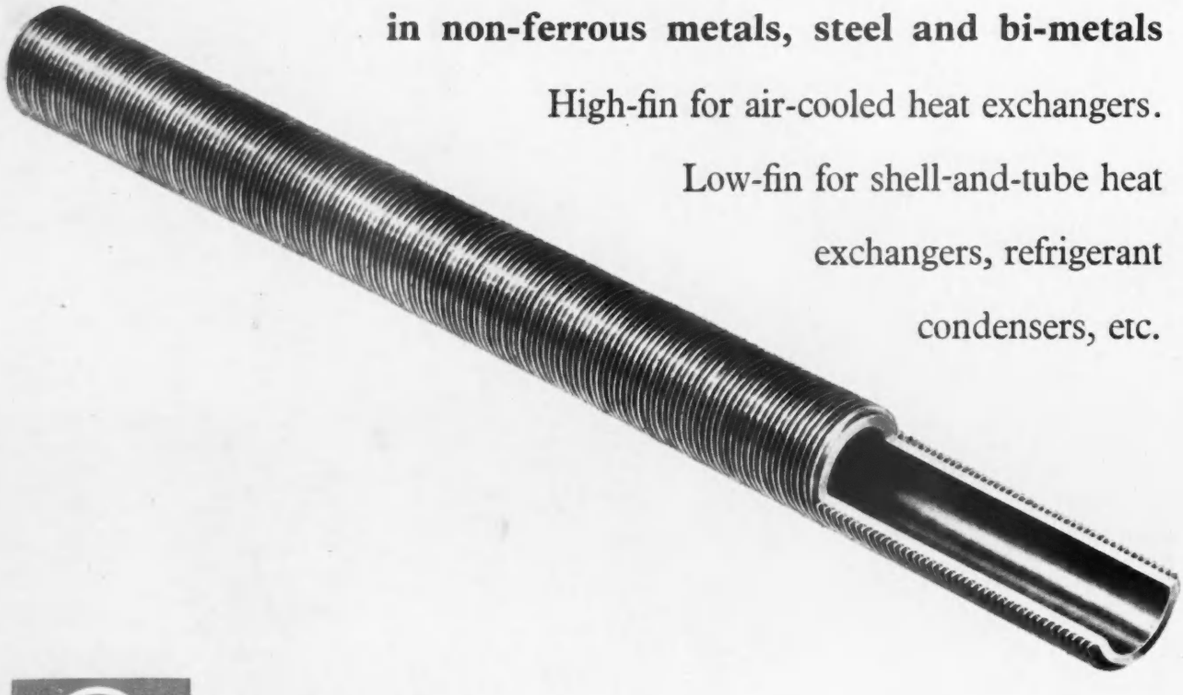

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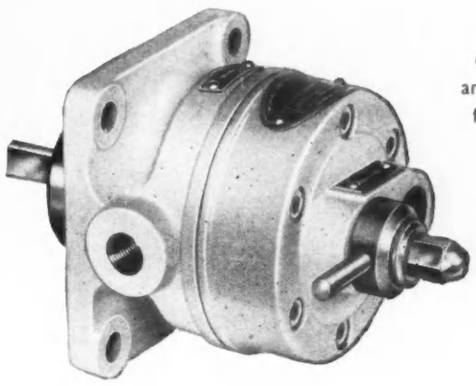

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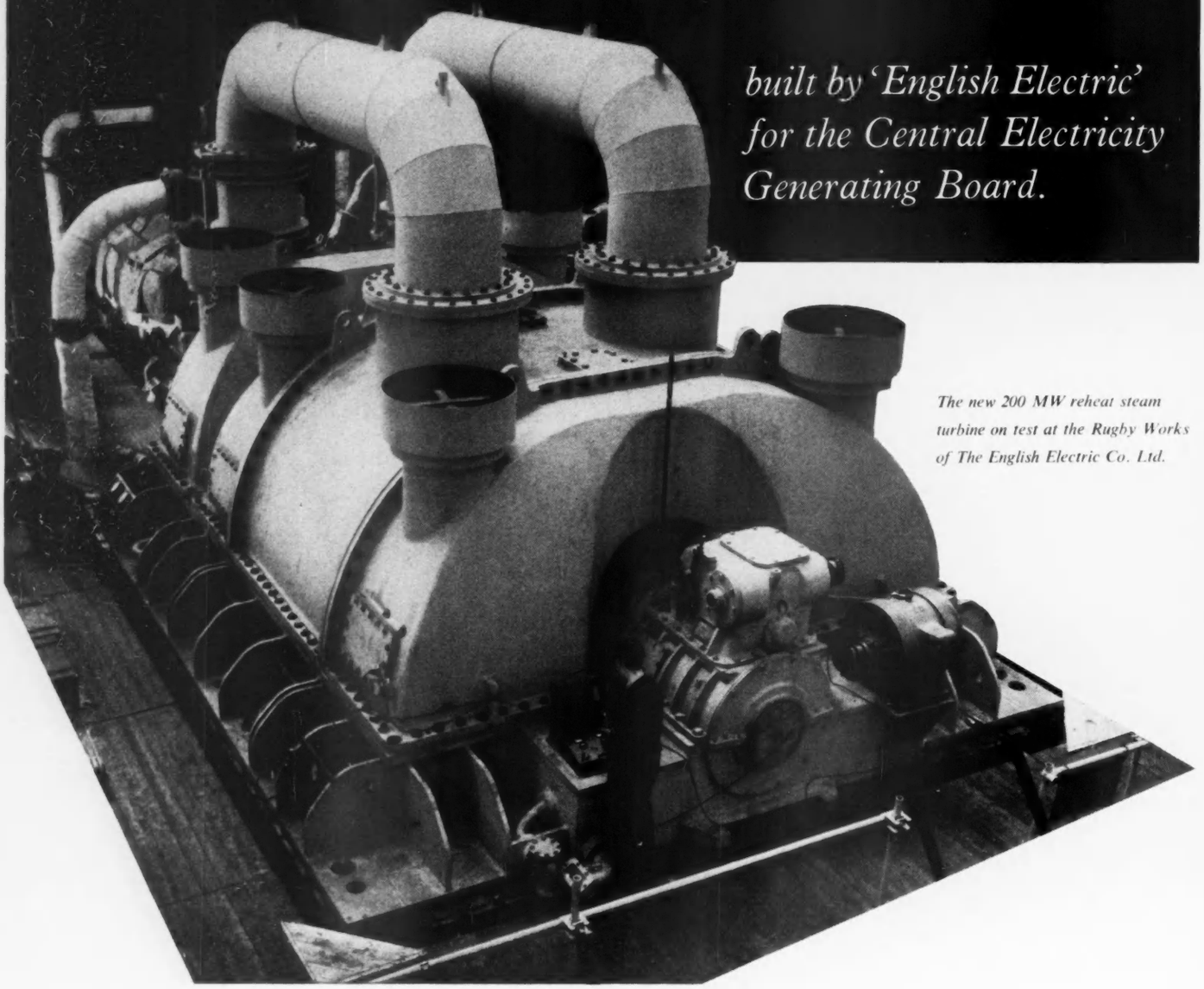

The new 200 MW reheat steam turbine on test at the Rugby Works of The English Electric Co. Ltd.

The first of the five 200 MW turbo-alternator units ordered from The 'ENGLISH ELECTRIC' Company for the Board's 1,000 MW power station at High Marnham is now installed.

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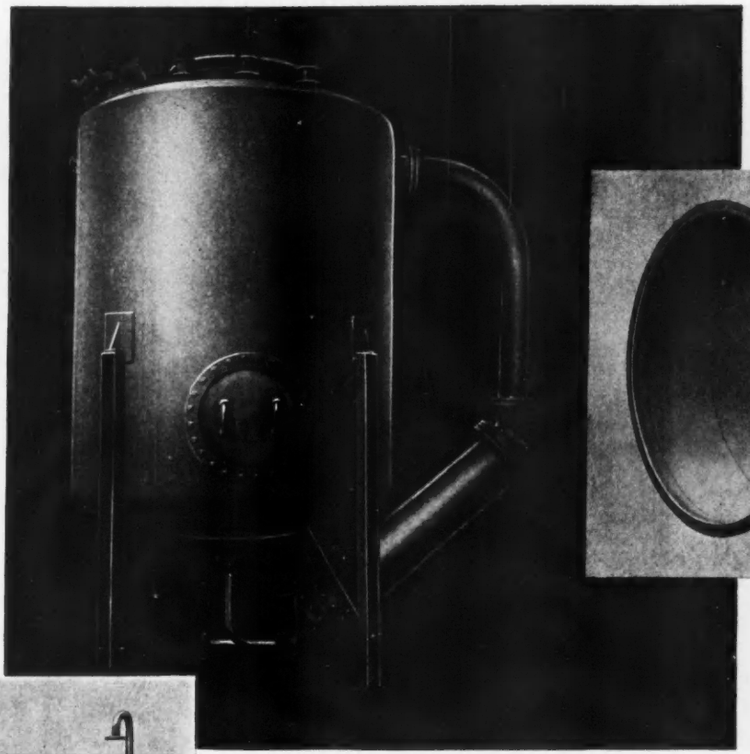
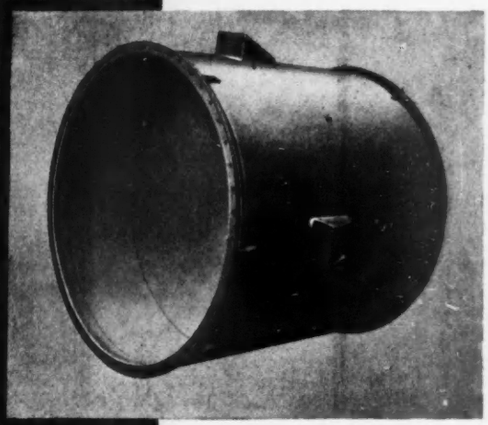


1,000 gall. kettle in ¼" copper. Lynx Quasi-arc welded.



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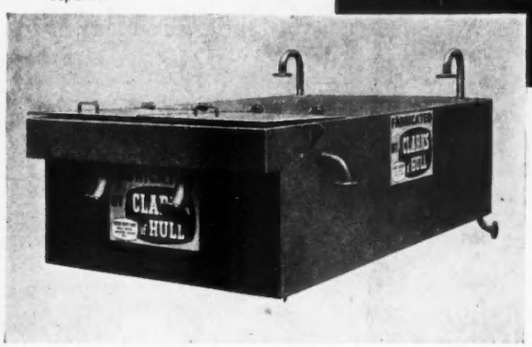

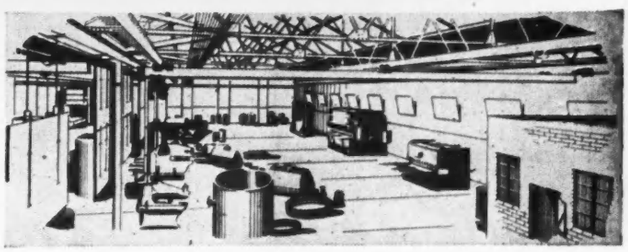

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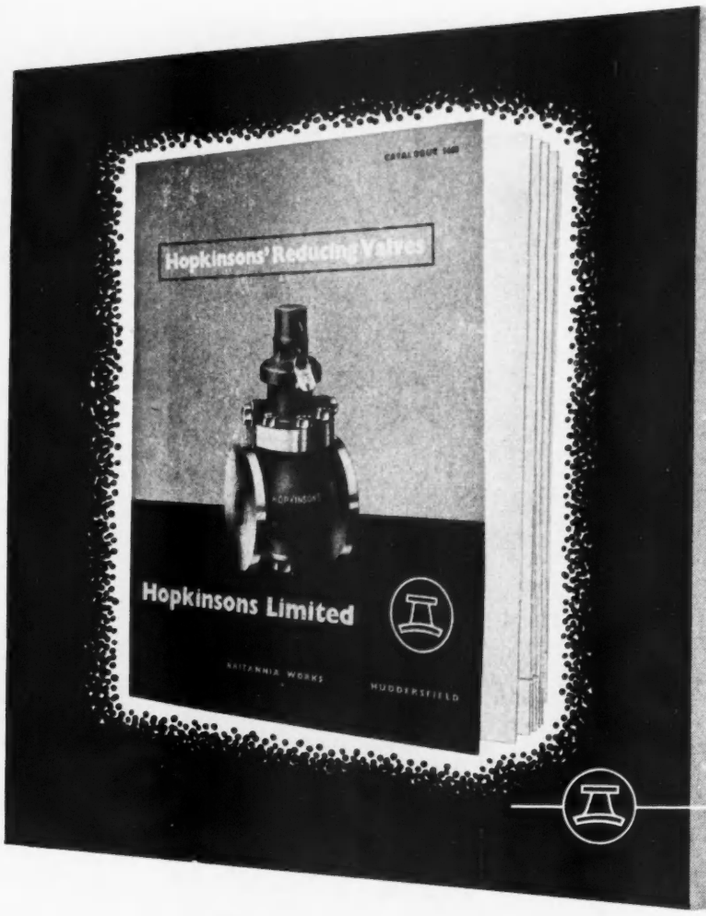

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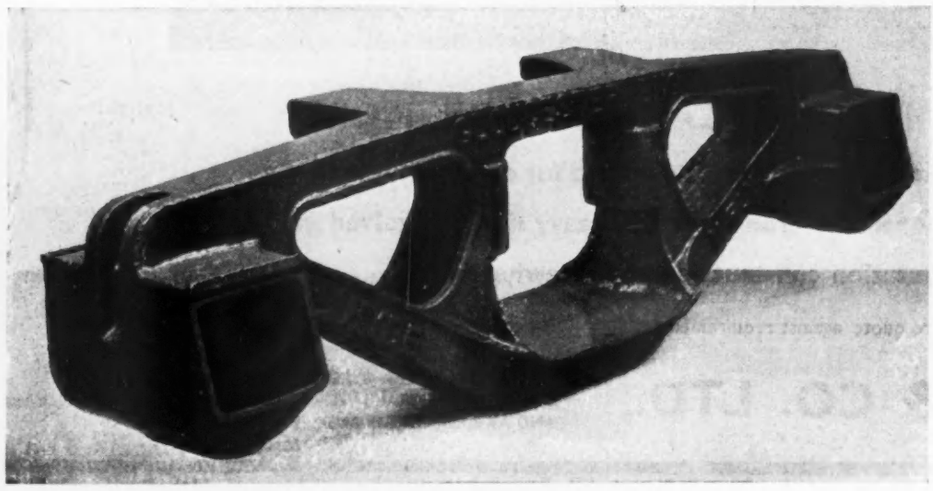

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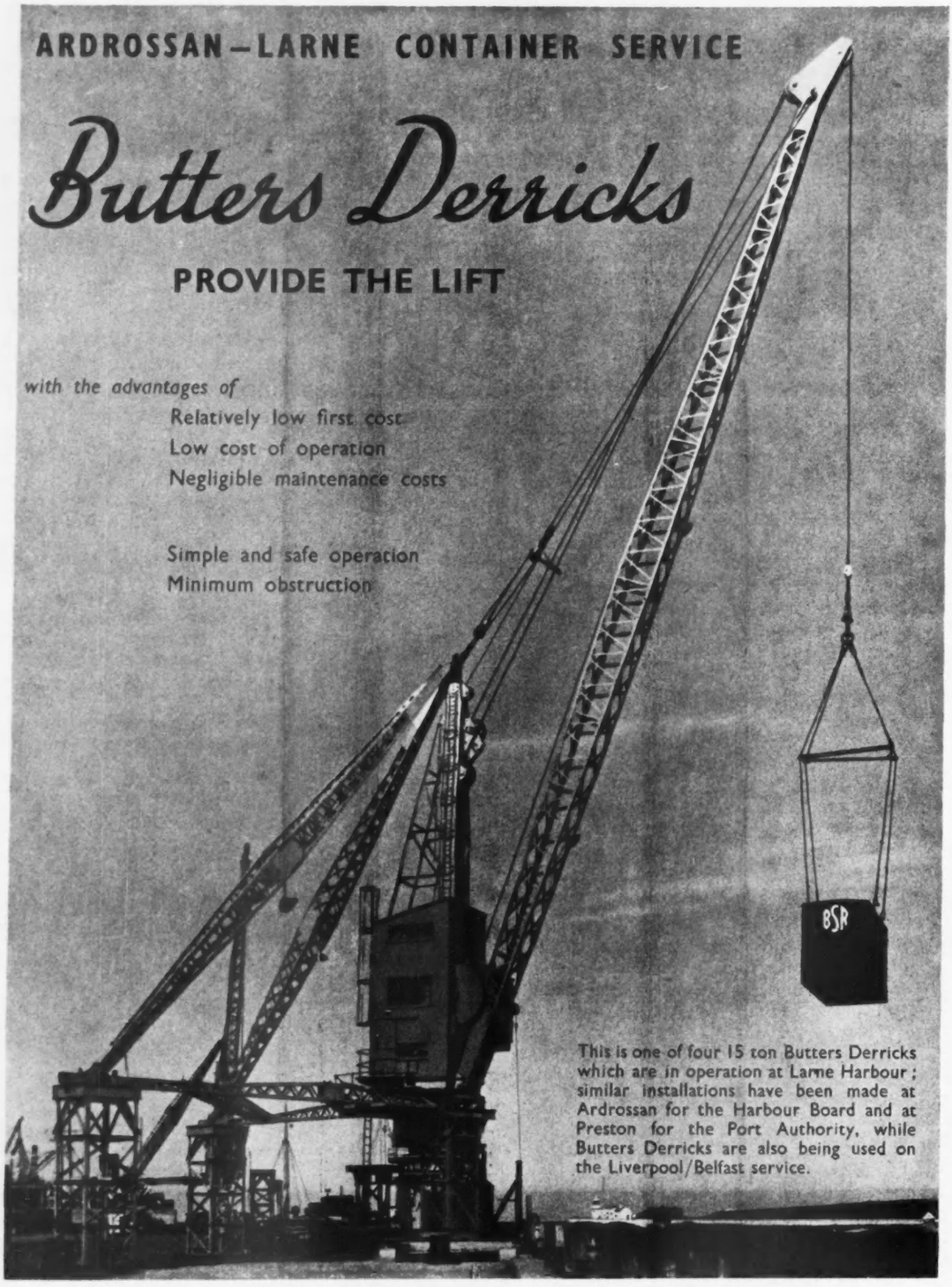

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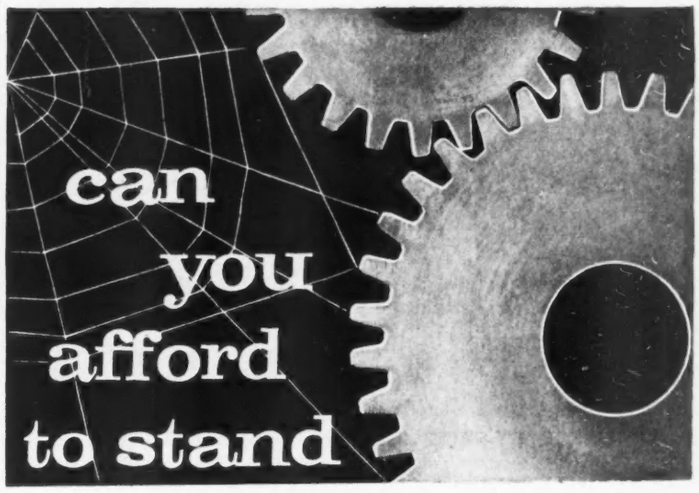

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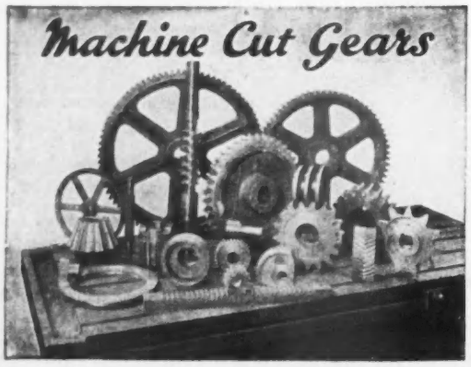

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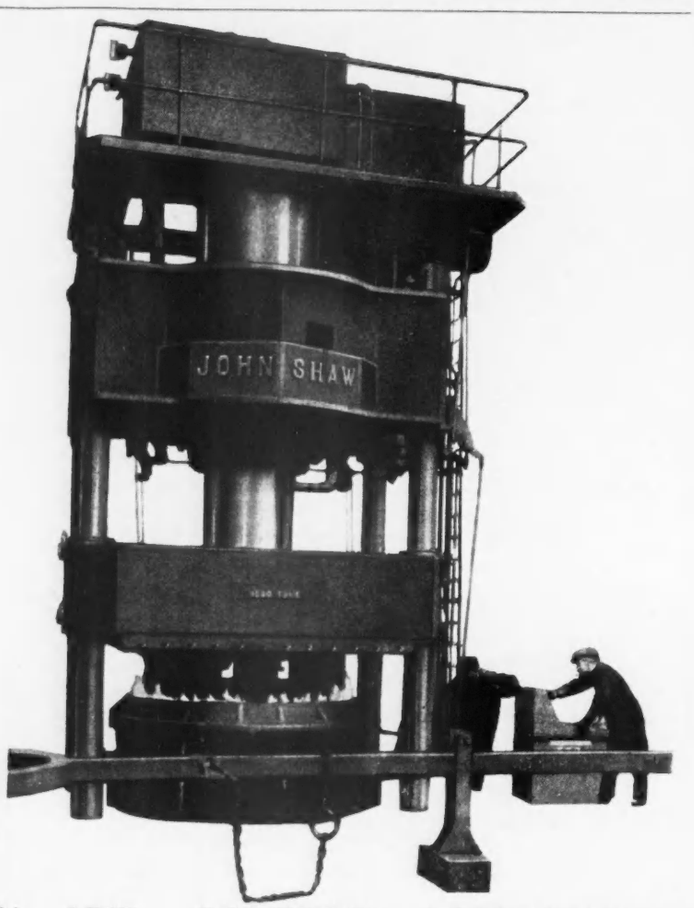

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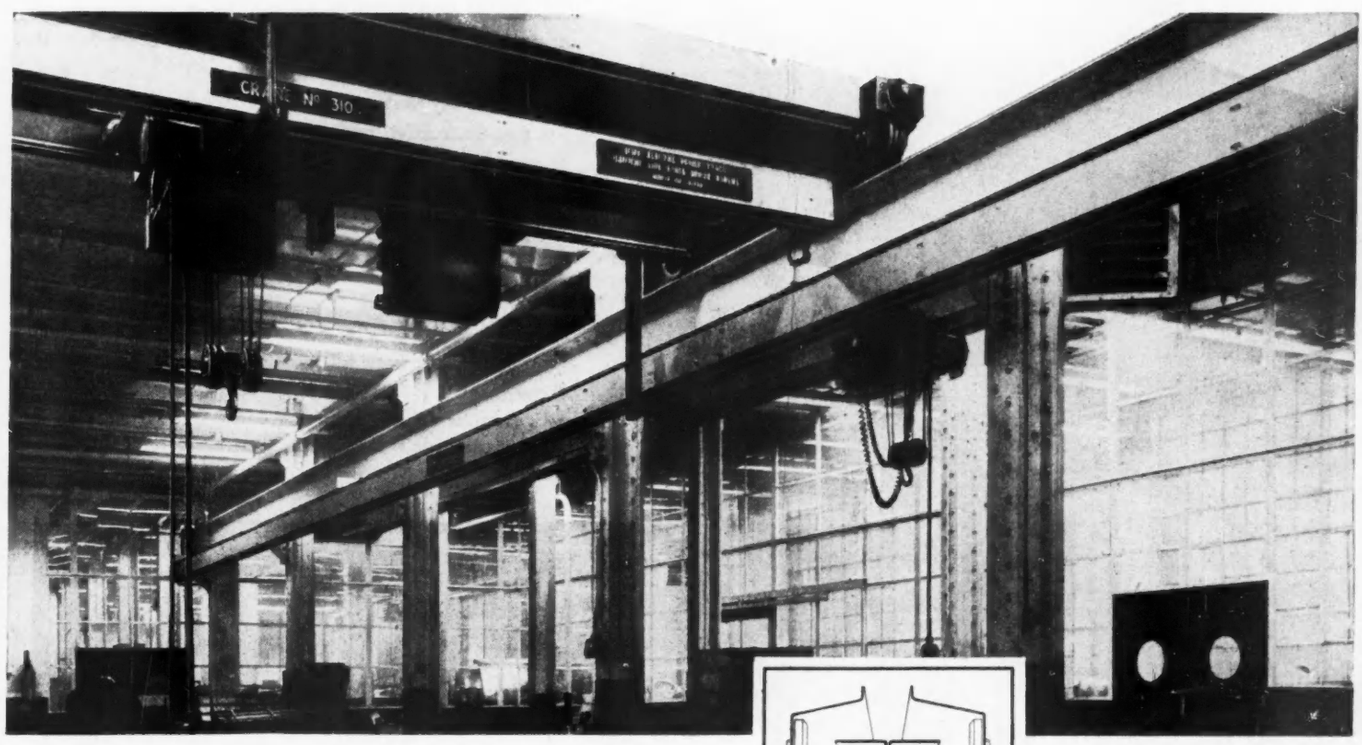

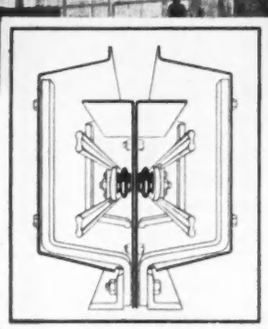

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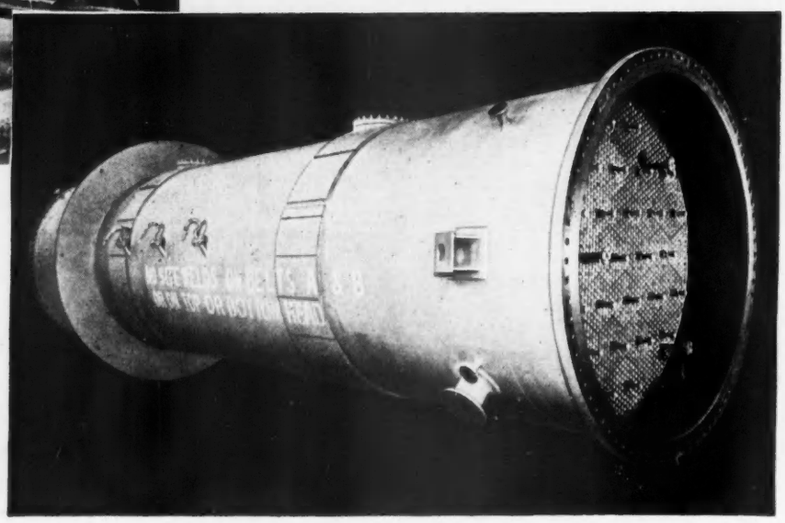

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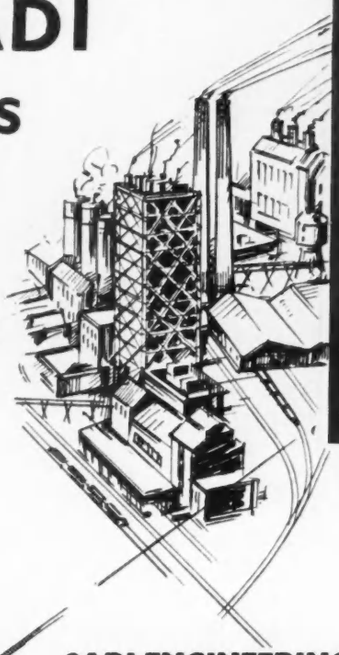

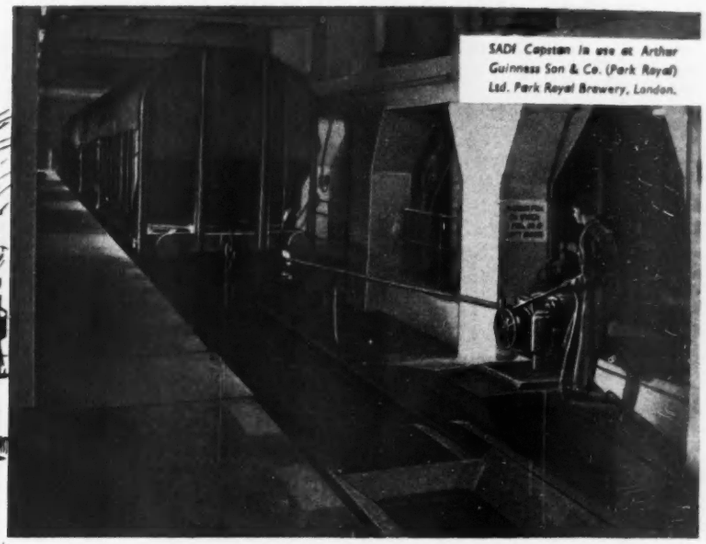

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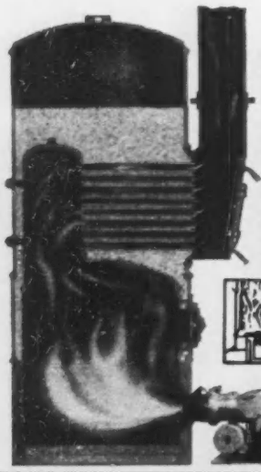

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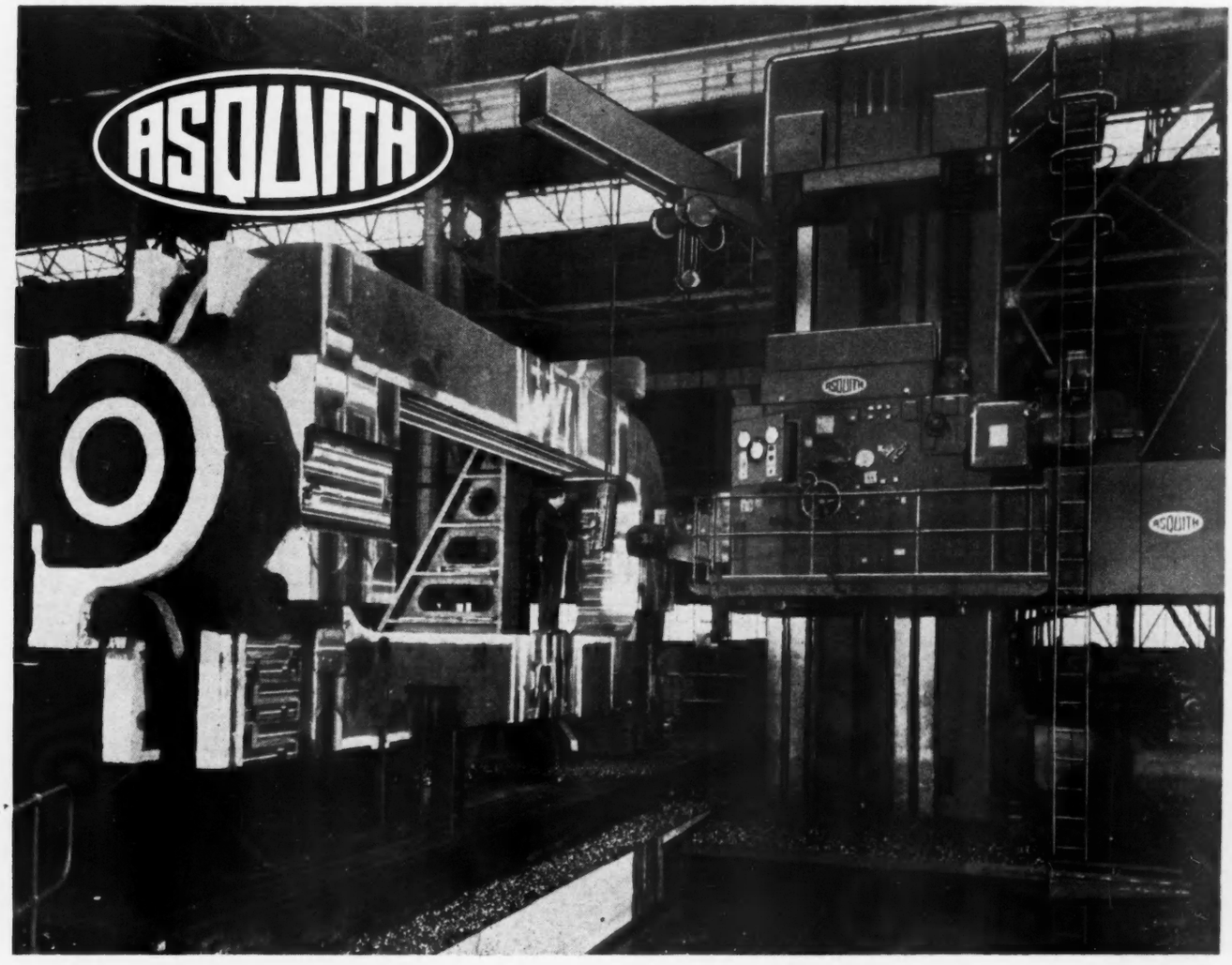
(Photograph by courtesy of the National Coal Board)



RAM TYPE *Horizontal Milling & Boring Machine at* DAVY-UNITED

The 10 in. Spindle Ram Type machine shown above is machining a 170 ton Mill Housing at the Darnall Works, Sheffield, of Davy and United Engineering Company Limited.

The exceptionally robust proportion of this Asquith machine can be appreciated from the illustration. A 28. in by 36 in. ram houses the milling sleeve and spindle, both of which travel with the ram. The milling sleeve which carries the cutter is 23 in. dia. and attachments for right angle milling, etc., are of adequate proportions for heavy duty work. Surfacing slides are available and when fitted obtain feed and hand adjustments from the slide of the machine, thus having all the features of built-in facing heads.

All Asquith Ram Type machines incorporate a steering control system which permits simultaneous control of both the horizontal and vertical feed motors to facilitate face milling of surfaces of irregular outline.

These Asquith machines are built in a range with spindle diameter 6 in., 7 in., 8 in., 10 in., or 11 in.

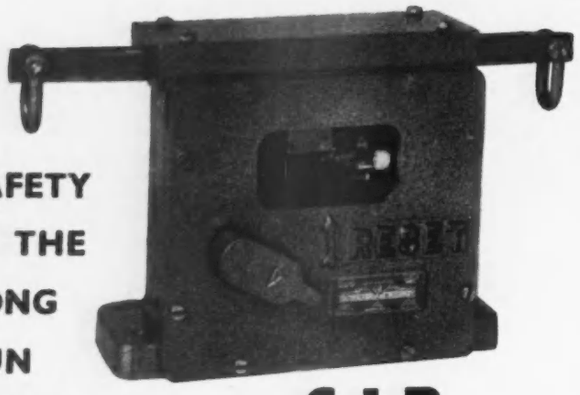
WILLIAM ASQUITH LTD.,
HALIFAX · ENGLAND

DA FOR HIGHER PRODUCTION

Sales and Service for the British Isles

DRUMMOND-ASQUITH LIMITED

KING EDWARD HOUSE, NEW ST., BIRMINGHAM *Phone: Midland 3431. Also at LONDON Phone. Trafalgar 7224 & GLASGOW Phone: Central 0922*



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MAGNETIC SAFETY TRIP WIRE SWITCH

Designed specially for use with conveyors and similar equipment, where long runs of machinery are in use, this C.J.R. safety device stops the driving motor (or applies a brake), at a touch of the trip wire. You owe it to yourself and your employees to fit this infallible safety device.

MANUFACTURERS OF INDUSTRIAL ELECTRONIC EQUIPMENT AND LOW VOLTAGE SAFETY SYSTEMS

C.J.R. ELECTRICAL AND ELECTRONIC DEVELOPMENT LIMITED
BICKFORD ROAD · WITTON · BIRMINGHAM 6

How important is

SURFACE FINISH CONTROL?

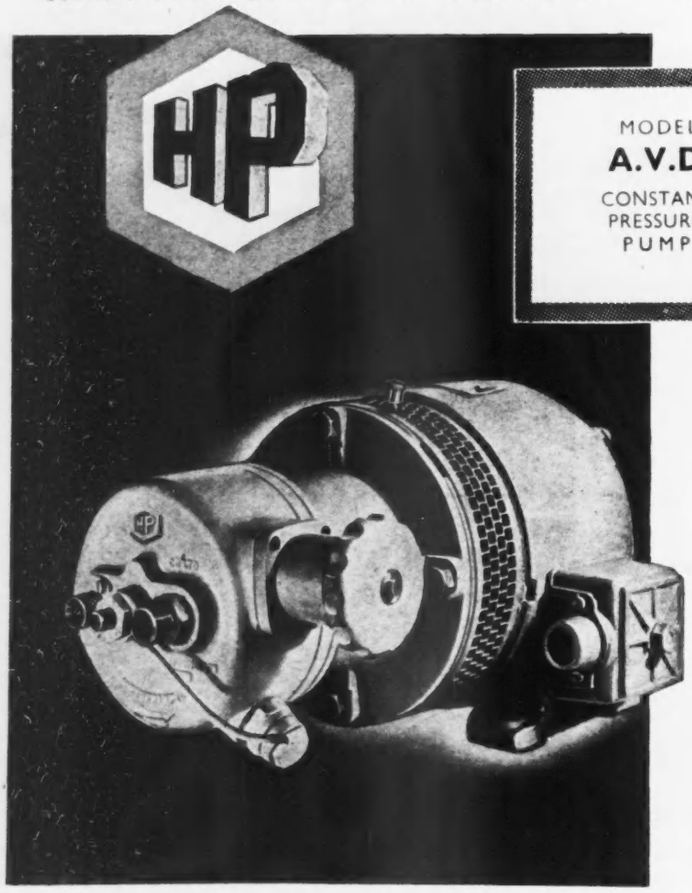
We are exhibiting at:—
6th EUROPEAN MACHINE TOOL EXHIBITION, PARIS.
Sept. 12—21st, 1959.
STAND No. 4F1.

Are your Draughtsmen, Foremen, Inspectors and Machinists surface finish conscious? If so your products will have a high reputation; if not, your products will not be classed as high quality. "RUBERT" Surface Roughness Scales provide a reference of calibrated Surface Roughness for comparison of machined surfaces by sight and touch and fulfil the need for a simple, dependable standard for visualising, selecting and specifying surface conditions for production work.
Whether you have electronic instruments to test Surface Roughness or not, your Draughtsman always needs Surface Roughness Standards to enable him to specify the required surface finish, and the Machinist cannot be without these because he must always have a comparison handy to tell him whether the finish is good enough, not good enough, or too good.

"RUBERT"
Surface Roughness Scales
are used by hundreds of the most prominent British Firms
ASK FOR LEAFLETS

RUBERT & CO. LTD.
ACRU WORKS, DEMMINGS ROAD, COUNCILLOR LANE, CHEADLE, CHESHIRE
Telephone: GATley 5855

HIGH PRESSURE OPERATION—POWER ECONOMY—SPACE SAVING



MODEL **A.V.D.**	MODEL **V.D.**	MODEL **F.D.**	MODEL **HI-LO**
CONSTANT PRESSURE PUMP	VARIABLE DELIVERY PUMP	FIXED DELIVERY PUMP	TWO STAGE PUMP UNIT

Offer noteworthy advantages of compactness, high efficiency, and smooth, silent operation.

MODEL A.V.D. is particularly suitable for Plastic moulding machines and other applications where it is necessary to maintain and regulate pressure for long periods with no flow, minimum power consumption and without overheating. Flow 1½ G.P.M., maximum pressure 2500 p.s.i.

MODEL V.D. is adjustable by manual operation for "flow control." The maximum pressure is 2500 p.s.i.

MODEL F.D. can be supplied for a flow of 1½ G.P.M. and maximum pressure 2500 p.s.i. (Continuous).

MODEL HI-LO. 2-stage Pump Unit.

AVAILABLE FOR IMMEDIATE DELIVERY

★ *Write NOW for fully illustrated literature, specifications and prices, and details of our comprehensive range of Air, Vacuum, and Hydraulic Equipment to Dept. E:—*

HYDRAULICS & PNEUMATICS LTD.

WULFRUNA WORKS, VILLIERS STREET, WOLVERHAMPTON. Tel: Wolverhampton 24456 Grams: Wulfruna Wolverhampton.

The study of acoustics...

faces up to the problems of noise generation and suppression in industry today, with particular reference to fan engineering equipment.
Keith Blackman have faced the facts created by these problems by erecting one of the best equipped, most scientifically designed Acoustic Laboratories available to industry in this country. It is now in service at their Tottenham works.
For further details write now for this fully illustrated and descriptive Publication No. 40 I

Depend on sound engineering by KEITH BLACKMAN

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Minimum Insurance Rates

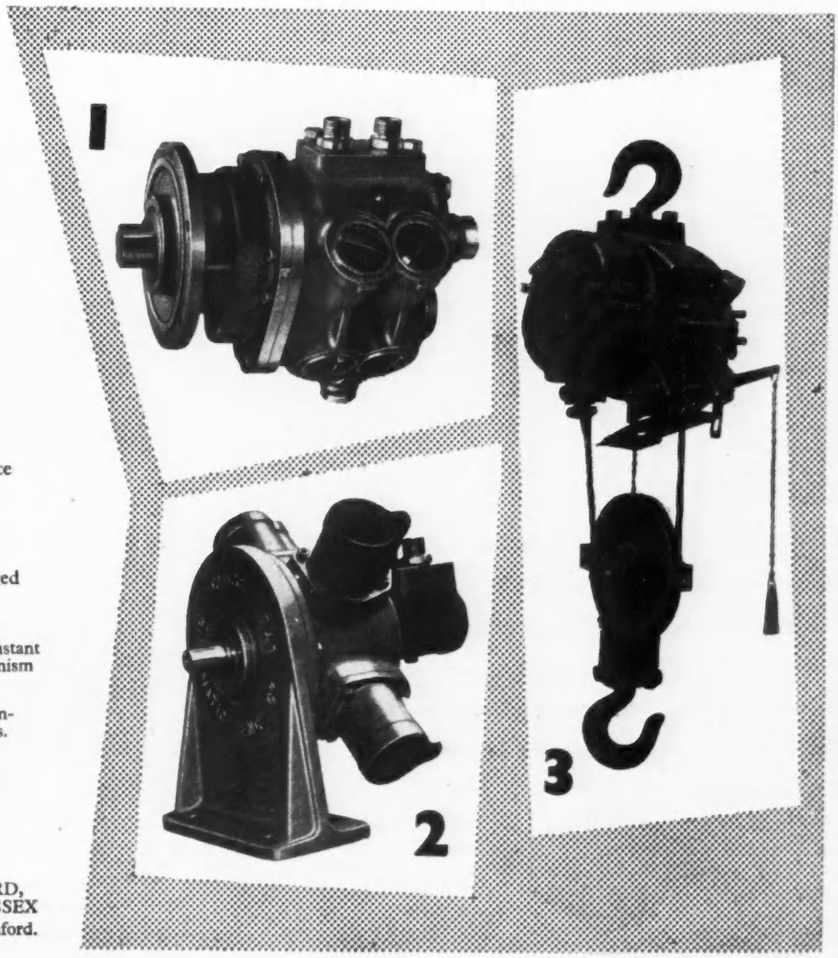
For Users of GLOBE PNEUMATIC EQUIPMENT

In premises where the fire risk is high, minimum insurance rates are subject to the use of Flame-proof equipment.
Globe Pneumatic Equipment complies fully with this requirement.
It should also be remembered that Globe Equipment is precision built for long life and hard work and is not damaged by overloading.
The machines illustrated are :—

1 The Vee Type Motor—A multi-cylinder design giving instant starting suitable for control systems, with reversing mechanism and infinitely variable speed.

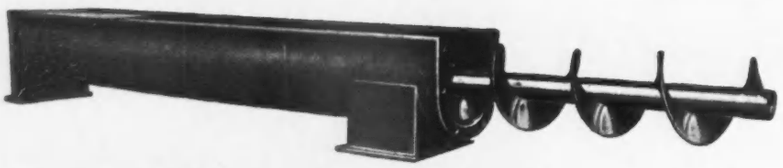
2 The Radial Type Motor—A version that has shown considerable air economy over ordinary rotary blade motors.

3 The Geared Wire Rope Motor Hoist—A lighter, stronger pneumatic block that remains unaffected by overload risks and extremes of temperature and moisture.



GLOBE **PNEUMATIC**
ENGINEERING COMPANY, LTD.
ASHTON ROAD, HAROLD HILL, ROMFORD, ESSEX

Telephone: Ingrebourne 43851/5 Telegrams: Pneumatoid Romford.



SCREW CONVEYOR

EMINENTLY SUITED FOR CONVEYING BULK MATERIAL

STANDARD INTERCHANGEABLE PARTS

50 cu. ft. hour to **4,500** cu. ft. hour Capacities

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Manufacturers with over 50 Years' experience — Offer the latest in

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THE MOST PRACTICAL WAY OF ELEVATING BULK MATERIAL AND OFFERING THE BEST POSSIBLE PROTECTION AGAINST FIRE AND EXPLOSION RISK.

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1 to 50 tons per hour Capacities

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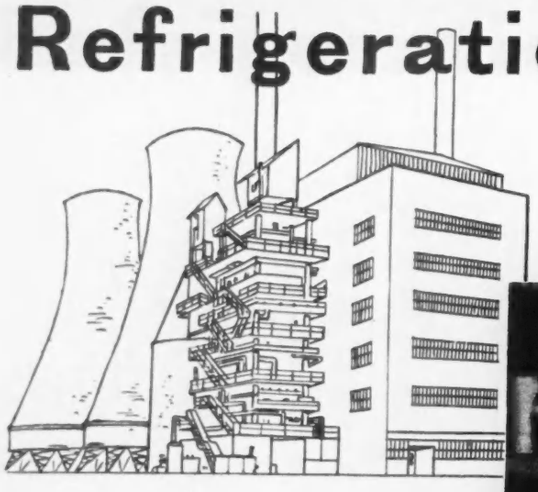
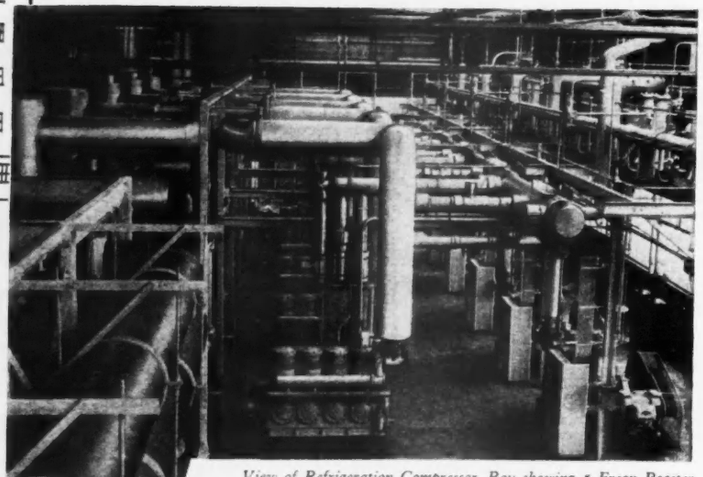
PATENTED AND TRADE MARK REG. U.S. PAT. OFF.

Phone: Gloucester 21055-6-7

Refrigeration in industry

Nuclear Research





View of Refrigeration Compressor Bay showing 5 Freon Booster Compressors, Type 9/4 and 5 Freon Compressors, Type 9/2. Photograph by permission of the United Kingdom Atomic Energy Authority.

For their factory at Capenhurst, the United Kingdom Atomic Energy Authority selected UDEC refrigeration. This extensive installation is but one of the many undertakings with which UDEC refrigeration engineers are currently concerned — ranging from food storage to plastics, brewing to chemical processing, dyestuffs to oil refining, etc.

UDEC

U. D. ENGINEERING CO. LTD.

ABBEY WORKS, CUMBERLAND AVENUE, PARK ROYAL, LONDON, N.W.10

Telephone: ELGar 6581

Refrigeration specialists to the industries of the World

UDE4R

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.

Inch Rate. 48/- per single column inch and pro rata. 12 lines to 1 inch. There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

Lineage Rate. 3/6 per line of approximately 6 words. Minimum 14/-.

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Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

***Advertisements for publication should be addressed to:*—Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565

PUBLIC APPOINTMENTS

NIGERIAN COLLEGE OF ARTS, SCIENCE AND TECHNOLOGY

SENIOR TECHNOLOGISTS OR TECHNOLOGISTS

Applications are invited for SENIOR TECHNOLOGISTS or TECHNOLOGISTS for the engineering laboratory and workshops for students preparing for University of London B.Sc.(Eng.) in Special Relationship.

Qualifications :

Civil : H.N.C. desirable and suitable experience.

Electrical : H.N.C. desirable and experience on maintenance and construction of electronic equipment and instrument maintenance.

Mechanical : H.N.C. or Final City and Guilds. Successful candidate required to assist in teaching engineering drawing and workshop technology.

Contract salary scales : Technologist, £654–£1116 p.a.; Senior Technologist, £990–£1260 p.a., both plus inducement addition of £180–£300 p.a. for overseas appointees and gratuity at £25 or £37 10s. for each completed 3 months' residential service. Entry point according to qualifications and experience.

Partly furnished quarters at one-twelfth basic salary rental. Tours 10–18 months, but leave normally taken in long vacation. Children's U.K. maintenance grant up to £150 p.a. and passages assistance.

Applications (6 copies), giving age, qualifications, experience and names of 3 referees, should be sent to The Council for Overseas Colleges, 12, Lincoln's Inn Fields, London, W.C.2, by 30th September, 1959. E7341

UNIVERSITY COLLEGE OF SWANSEA

LECTURESHIP IN ELECTRICAL ENGINEERING

A vacancy exists for a LECTURER IN ELECTRICAL ENGINEERING at the University College of Swansea, a constituent college of the University of Wales. It is desired to appoint an applied scientist or engineer interested in either the design and utilisation of rotary machines and ancillary equipment, or the design of servo-mechanisms and electrical control systems.

Applicants should hold a good degree and have not less than three years' post-graduate experience of research or design in one of these fields, and be capable of instructing undergraduate and post-graduate students. It is expected that a lecturer shall carry out advanced studies in some aspect of his particular field of interest and teach his subject from a modern standpoint.

The salary scale of a Lecturer is £900 by £50 to £1350 by £75 to £1650, but the initial appointment will be made at a point on this scale appropriate to the experience of the successful applicant. F.S.S.U. benefits. There is also a child allowance of £50 per child per annum.

Further particulars about conditions of employment and the teaching and research facilities of the electrical department, can be obtained from the Registrar, University College, Singleton Park, Swansea, with whom applications (one copy) should be lodged before September 30th, 1959. E7318

UNIVERSITY OF GLASGOW

MECHANICAL AND ELECTRICAL ENGINEERS

The University of Glasgow, with the support of the Nuffield Provincial Hospitals Trust, will shortly establish a small Research Unit to study certain engineering problems which arise in connection with the construction and maintenance of hospital buildings. The provision of specifically engineering services accounts for an increasing proportion of hospital costs, and experience has disclosed a considerable variation in the degree of success of these services. The assignment is expected to occupy two years in the first instance, with a possible extension.

The University wishes to appoint MECHANICAL and ELECTRICAL ENGINEERS to this Unit, and invites applications from candidates with good academic and professional qualifications. The appointments will be in two grades with salary ranges of £1300–£1500 per annum and £1500–£1800 per annum respectively, together with necessary travel and other expenses. Further particulars may be obtained from the Secretary of the University Court, The University, Glasgow, W.2.

ROBT. T. HUTCHESON,
Secretary of University Court.
E7296

PUBLIC APPOINTMENTS

MIDDLESEX COUNTY COUNCIL EDUCATION COMMITTEE

TWICKENHAM TECHNICAL COLLEGE, EGERTON ROAD, TWICKENHAM, MIDDLESEX

SENIOR LECTURER

A well-qualified SENIOR LECTURER is required to teach Mechanical Engineering subjects, preferably including Structures and/or Hydraulics in Higher National Diploma and Post-Higher National Certificate Courses.

Good industrial and preferably some teaching experience looked for.

Salary in accordance with the Burnham (Technical) Report.

Further particulars from the Principal (enclose s.a.e.). Closing date 1st October, 1959.

C. E. GURR, M.Sc., Ph.D.,
Secretary to the Education Committee.
E7270

CENTRAL ELECTRICITY GENERATING BOARD

EASTERN DIVISION

APPOINTMENTS

Applications are invited for the following appointments in the Generation Department at Divisional Headquarters (Cockfosters) :

GENERAL ASSISTANT ENGINEERS (S.V. No. 1166).

Salary, Class AX/DX, Grade 9, £610 by £15 to £685/£745 per annum, inclusive of London Weighting.

The commencing salary will depend upon the qualifications and experience of the successful applicants.

Duties will include assisting in testing and investigation work concerned with assessing plant performance and as a service for plant maintenance and some research and development work. These duties will involve visiting generating stations within the Divisional area, and will provide a wide field of training and experience which will be of value for promotion to higher appointments within the Industry.

Applicants should preferably hold a Higher National Certificate or equivalent, previous experience in a Generating Station would be an advantage.

ENGINEERING DRAUGHTSMAN (CONSTRUCTION SECTION) (S.V. No. 1167).

Salary, Schedule D, Grade 6, £660 by £20 to £780 per annum inclusive of London Weighting.

The duties of the applicant appointed will include the preparation of drawings under supervision of mechanical and civil works associated with high voltage transmission lines and substations.

Applications, quoting the appropriate Staff Vacancy Number and reference 2/10818, stating age, qualifications, experience and present position should be sent to the Controller, Central Electricity Generating Board, Eastern Division, West Farm Place, Chalk Lane, Cockfosters, Barnet, Herts, by the 19th September, 1959.

W. N. C. CLINCH,
Controller.
E7319

CITY OF NOTTINGHAM

WATER DEPARTMENT

APPOINTMENT OF DISTRIBUTION ENGINEER

Applications are invited from Chartered Civil Engineers, with considerable experience of main laying and the control of workmen, for the permanent pensionable appointment of Distribution Engineer. Salary Grade "A," £1290 by £50 to £1390.

A list of the responsibilities and duties of the post may be obtained from the Engineer and General Manager. Appointment subject to medical examination and terminable by one month's notice on either side.

Applications, setting out details of general and technical education and practical experience, and giving the names of two referees, should reach the Engineer and General Manager, Water Offices, Castle Boulevard, Nottingham, not later than 28th September, 1959.

T. J OWEN,
Town Clerk.
E7333

PUBLIC APPOINTMENTS

BRITISH TRANSPORT COMMISSION

APPOINTMENTS

British Transport Commission invites applications for the following posts :

Research Station, Docks and Waterways, Hayes Road, Southall.

SCIENTIFIC OFFICER. Salary Range £1045 to £1150.

Post A.—Candidates should have good degree in Physics or Engineering with mathematical ability and knowledge of hydraulics. Practical experience in research or engineering an advantage.

Chief Electrical Engineer's Department, at 14, Melbury Terrace, Marylebone, London, N.W.1.

SENIOR SCIENTIFIC OFFICERS. Salary according to qualifications and experience, subject to a maximum of £1315.

Good degree and post-graduate research experience. Industrial training an advantage. Initially may be required to spend two to three years on research in Universities or industrial firms.

Post B.—Application of modern techniques such as semi-conductors or magnetic amplifiers to electric traction problems. Thorough grounding in electromagnetic theory required.

Post C.—Thermal problems associated with electric equipment. Good knowledge of theory of heat transfer and expertise in all forms of temperature measurement essential.

TECHNICAL ASSISTANTS. Salary range £833 to £903.

Post D.—Engineer or Physicist preferably possessing degree or equivalent qualification with some experience in application of modern instrumentation with special emphasis on electronic methods.

Post E.—Engineer qualified for A.M.I.E.E. or A.M.I.M.E. and having experience of conduct of experiments.

TECHNICAL ASSISTANT. Salary range £943 to £985.

Post F.—Engineer with degree or equivalent qualification, experiences in application of modern instrumentation with special emphasis on electronic methods.

Superannuation scheme. Certain travel facilities. Medical examination. Write, quoting post reference and stating age, qualifications and experience to Director of Establishment, British Transport Commission, 222, Marylebone Road, London, N.W.1, within 7 days. E7320

FEDERAL GOVERNMENT OF NIGERIA

ELECTRICAL INSPECTOR

ELECTRICAL INSPECTOR, under the Chief Inspector, to inspect electrical supply undertakings and large consumers' installations, including factories, mines and oil wells, and to investigate and conduct enquiries into electrical accidents.

Contract appointment. Salary range : £1290–£1674. Gratuity of £37 10s. for each three months' satisfactory service. Quarters at moderate rent. Free passages. Allowance for children maintained in United Kingdom. Generous home leave.

Candidates must be A.M.I.E.E. or be exempt the Institution's examination and have been apprenticed to an electrical supply undertaking or large industrial undertaking with at least 7 years' experience of responsibility involving the planning, erection and maintenance of electrical transmission and distribution systems or works electrical plants. A thorough knowledge of electrical supply and wiring regulations as they apply in the United Kingdom is essential.

Write, Director of Recruitment, Colonial Office, London, S.W.1, stating full names, age, qualifications and experience, quoting BCD 99/14/014. E7306

MINISTRY OF SUPPLY

ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH

TECHNICIAN

Ministry of Supply requires a TECHNICIAN at Royal Aircraft Establishment, Farnborough, to supervise team engaged on aircraft servicing. Qualifications : recognised engineering apprenticeship ; thorough and up-to-date knowledge of servicing methods for modern aircraft ; experience in overhauling aircraft components an advantage. O.N.C., appropriate C. and G. Final Certificates, or equivalent, desirable. Salary £680 (age 26) to £850 p.a.—Application forms from Manager (P.E.2065), M.O.L and N.S., Professional and Executive Register, Atlantic House, Farringdon Street, London, E.C.4. E7300

PUBLIC APPOINTMENTS

HEAVY ELECTRICALS LIMITED, BHOPAL

(GOVERNMENT OF INDIA UNDERTAKING)

ADVERTISEMENT No. 57

ELECTRICAL AND MECHANICAL ENGINEERS

Applications are invited from qualified ELECTRICAL AND MECHANICAL ENGINEERS of Indian nationality for posts with Heavy Electricals, Limited, which will arise during the next 3/4 years. Among the posts to be filled will be the following :—

(1) Manufacturing Superintendents.
(2) Departmental Chief Engineers for :
(a) Traction.
(b) Industrial Motors.
(c) Heavy Rotating Plant.
(d) Applications.

Selected candidates will be recruited as Senior Engineer Trainees and will undergo training for approximately three years before joining duty at Bhopal. They should be between 33–38 years of age (relaxable) and possess a Degree in Mechanical or Electrical Engineering, and have at least ten years' experience related to electrical rotating machines.

During training they will receive Rs.600/– p.m. maintenance allowance, plus home stipend. When posted at Bhopal pay will be in the grade of Rs.1300–1600 p.m.

Further details and details of application fee payable on request from the High Commission of India, Establishment Department, India House, Aldwych, London, W.C.2, who will receive applications up to the 25th September, 1959. E7310

WOLVERHAMPTON CORPORATION

WATER UNDERTAKING

APPOINTMENTS

A. ENGINEERING ASSISTANT for new works, £785–£1070 p.a. (Special Grade).

B. DEPUTY SUPERINTENDENT, Bratch Pumping Station, Wombourn, £610–£765 p.a. (A.P.T. I).

N.J.C. service conditions, posts pensionable, medical examination. House to rent in each case.

Further particulars of Post B from, and applications naming two referees to, Water Engineer and Manager, Water Offices, 37, Merridale Road, Wolverhampton, by 21st September, 1959. E7304

HEAVY ELECTRICALS LIMITED, BHOPAL

(GOVERNMENT OF INDIA UNDERTAKING)

ADVERTISEMENT No. 58

ELECTRICAL AND MECHANICAL ENGINEERS

Applications are invited from qualified ELECTRICAL AND MECHANICAL ENGINEERS of Indian nationality for posts with Heavy Electricals Limited, which will arise during the next 3/4 years. Among the posts to be filled will be the following :—

(1) Supervisory Staff, including Manufacturing Assistant Superintendents ; Departmental Assistant Chief Engineers ; Chief Estimators ; Chief Draughtsmen ; and junior posts.

(2) Draughtsmen.

Selected candidates will be recruited as Engineer Trainees and will undergo training for approximately three years before joining duty at Bhopal. They should be between 23–35 years of age and possess a Degree/Diploma in Mechanical or Electrical Engineering, and have at least two years (for Supervisory Staff) and five years (for Draughtsmen) experience related to electrical rotating machines.

During training they will receive Rs.600/–p.m. maintenance allowance plus home stipend. When posted at Bhopal pay will be in the grade of Rs.600–1150/–p.m. or Rs.350–850/– p.m. (for Supervisory Staff) and Rs.350–850/–p.m. (for Draughtsmen).

Further details and details of application fee payable on request from the High Commission of India, Establishment Department, India House, Aldwych, London, W.C.2, who will receive applications up to the 25th September, 1959. E7309

Classified Advts. continued on page 138

SITUATIONS VACANT

ENGINEERING IN MEAT PROCESSING

J. SAINSBURY, LTD.

Multiple Provision and Meat Distributors,

announce that the expansion in the trade for pork and manufactured pork products creates new opportunities in the Engineering Departments of the main meat products factory at Blackfriars, London, S.E.1, and the abattoir and establishment at Little Wratting, Haverhill, Suffolk.

Vacancies are as follows :—

1. At the Blackfriars factory,

AN ENGINEERING SUPERINTENDENT

to control all existing Engineering Supervisors and their staffs, the appointee to be responsible to the Works Engineer. Previous supervisory experience in factory engineering with practical knowledge of maintenance sections, is essential, as is a thorough knowledge of steam raising and refrigeration plants and general factory services and machinery.

2. At Little Wratting,

A WORKS ENGINEER

to control all engineering work and personnel. Experience and qualifications similar to those required for (1) above, but since this appointee will be responsible direct to the Manager of the Factories and Abattoir Engineering Department at Blackfriars, he must particularly have the ability to act on his own initiative and to liaise with contractors, when necessary.

The appointments are permanent and pensionable and for both the commencing salary will be within the range £1300–£1550, according to qualifications and experience.

Applications, giving full details of age, qualifications and experience, should be addressed to :—

The Personnel Manager (E. D.), J. Sainsbury, Ltd.,
Stamford House, Stamford Street, London, S.E.1.

E7302 A

SITUATIONS VACANT

RONEO LIMITED

require DRAUGHTSMEN, both Design and Detail for their programme of expansion in the manufacture of Steel Office Equipment.

Vacancies exist for :

2 Design Draughtsmen, experienced, qualified and capable of development work in this field

and

4 Detail Draughtsmen, with experience preferred, but applications will be considered from Detailers willing to apply their knowledge and skills.

A Pension Scheme, good working conditions, and salary commensurate to ability are offered.—Please write, giving full details of age, experience, qualifications, &c., to the Personnel Manager, Roneo Works, Romford, Essex.

E7291 A

SITUATIONS VACANT

"VSG" HYDRAULICS

VICKERS-ARMSTRONGS (ENGINEERS), LTD., WEYMOUTH, DORSET

DESIGN DRAUGHTSMEN required. Preference given to those having experience of hydraulic systems and power transmission, and holding H.N.C. (Mechanical). Also two vacancies for ELECTRO-MECHANICAL DRAUGHTSMEN.

Contributory Pension Scheme and Sports Club facilities.

Apply by letter in first instance, giving full details of experience and salary required.

E7285 A

CHIEF PRODUCTION AND METHODS ENGINEER

Applications are invited for this senior appointment with a large, expanding and progressive Company of precision engineers in the West Riding. Excellent residential and educational facilities in the immediate surroundings. Initial salary about £2000 p.a., plus bonus and non-contributory pension with excellent prospects of advancement.

The Chief Production and Methods Engineer will be responsible to the Works Director for departments of some 300 people engaged on production engineering in the widest sense, including the development of automatic handling equipment and automation. This involves work-study, process planning, machine loading and especially the design and manufacture of machine tools, jigs, small tools and gauges.

Essential qualifications are strong production engineering background, with a wide knowledge of the design and manufacture of jigs, tools and machine tools ; of hydraulic and electrical circuits as applied to machine tools, and of modern production management techniques, including work-study and production planning and control. Must also have practical tool-room experience and the ability to lead and develop a team. A.M.I.Mech.E. is desirable.

Please write briefly in first instance, quoting reference No. 212, to :

AA LTD

ASHLEY ASSOCIATES LTD.
PETER HOUSE, MANCHESTER 1.
RETAINED TO ADVISE ON THIS APPOINTMENT
The strictest confidence will be observed and no details of candidates will be passed to clients without candidates' permission.

E7286 A

ATOMIC ENERGY ESTABLISHMENT, WINFRITH, DORSET

REACTOR RESEARCH

Graduates with First or Second Class Honours in Physics, Mathematics or Engineering are required for reactor research. The initial programme includes work on high-temperature, gas-cooled systems and, in particular, the O.E.E.C. "Dragon" project. The field of work will include fluid dynamics, convective, conductive and radiative heat transfer and mass transfer. In all these fields exacting problems involving the development of new techniques and technology will be encountered.

Experimental experience, particularly in heat transfer or fluid dynamics, is essential for senior posts, and experience in high-temperature technology will be an advantage in all cases.

Salary within the range £675 to £2155, according to age and experience.

Housing and superannuation schemes.

Send POST CARD for application form and further details to :—

Personnel Branch (W.151 25),
U.K.A.E.A.,
A.E.E., Winfrith, Dorchester, Dorset,
not later than October 17th, 1959.

E7272 A

UNILEVER

have vacancies for

ELECTRONIC ENGINEERS

AT THEIR LONDON HEADQUARTERS

Selected candidates will be required to assist in the design, construction, installation, and operation of equipment for applying the most advanced automation techniques to manufacturing processes and office systems.

Applications are invited from engineers between the ages of 25 and 35 having a degree in science or engineering or an equivalent qualification. A recognised apprenticeship or at least three years' industrial experience is desirable.

Applications, giving details of training qualifications and experience, should be addressed to Head Office Staff Department (WF 42), Unilever House, Blackfriars, London, E.C. 4.

E7217 A

THE NELSON RESEARCH LABORATORIES
OF
THE ENGLISH ELECTRIC COMPANY LIMITED
Have vacancies for :—

ENGINEERS AND PHYSICISTS

(a) To work on interesting mechanical and heat transfer problems connected with

THERMO-NUCLEAR DEVICES — LIQUID METAL PUMPS
TRANSFORMERS — RECTIFIERS
ROTATING ELECTRICAL MACHINES — THERMO-ELECTRIC EQUIPMENT

Posts are available for experienced Mechanical or Electrical Engineers, Graduates, H.N.D. or H.N.C. men at levels of seniority appropriate to qualifications and experience.

(b) For experimental and development work on NEW TYPES OF ELECTRICAL MACHINES, including insulating systems for high-temperature machines. This post calls for H.N.D. or H.N.C. in Electrical Engineering, with endorsements, and some experience in Electrical Engineering.

(c) Investigation into the WEAR AND FRICTION characteristics of rubbing surfaces on a fundamental basis. Research on various aspects of SOLID STATE PHYSICS, including fundamental work on Magnetism and Semi-Conductor Materials. Previous experience in these fields is not necessary, but a sound basic knowledge is essential.

POWER ENGINEERS

To work on problems connected with HIGH-POWER PLANT AND TRANSMISSION. Posts are available at various levels of seniority, Degree or equivalent, H.N.D., H.N.C. or O.N.C. Some experience of Heavy Power Plant and associated electronic equipment is most desirable.

The Company offers an attractive superannuation scheme and the Laboratories are situated in pleasant countryside on the outskirts of Stafford.

Please write, giving full details of experience and qualifications, to Dept. C.P.S., Marconi House, 336-7, Strand, W.C.2, quoting reference E 916B.

E7295 A

NORRIS CONSULTANTS LTD.,

in view of a two-year expansion programme, require for their London and Bristol Offices and elsewhere in the U.K., Senior and Junior Engineers, Designers and Draughtsmen in the following fields.

CIVIL ENGINEERING DIVISION

Reinforced Concrete, Heating, Ventilating, Air Conditioning, Refrigeration, Pipework and General Services, Structural Steelwork.

PRODUCTION & MECHANICAL DIVISION

Special purpose machines, Transfer Systems, Jigs and Tools, General mechanical, Mechanical Handling, Electrical (Heavy and Light current).

Salary scales up to high level in accordance with age, experience, technical and professional qualifications. Pension and Insurance schemes. Write or telephone Head Office, Beacon House, Queens Road, Clifton, Bristol. Tel. : Bristol 3-6817, or those requiring appointments in London Area, write or telephone : 76, Victoria Street, S.W.1. Tel. : VIC 4675.

E7020 A

SITUATIONS VACANT

DESIGN ENGINEERS AND DRAUGHTSMEN ELECTRICAL.—Consulting engineers, handling a variety of design projects have vacancies for various grades of Electrical Designers and Draughtsmen. Pension scheme and three weeks' annual holiday after qualifying periods.—Norris Brothers, Limited, 62, Church Road, Burgess Hill, Sussex. E7284 A

DESIGN ENGINEER required in an expanding Technical department dealing with marine reduction gears and V.P. propellers. Good salary for experienced man with right technical background. Pension scheme. Applications to the Technical Manager, giving full details of education, qualifications, age, experience and present salary.—MODERN WHEEL DRIVE, LTD., Lindo Lodge, Chesham, Bucks. E7276 A

DESIGN ENGINEER.—An engineer is required by Imperial Smelting Processes, Ltd., to participate in the design and development of furnaces and ancillary plant for the Imperial Smelting blast furnace process for the simultaneous smelting of zinc and lead. Applications are invited from qualified engineers, preferably possessing a First Class Honours Degree, together with sound experience, including design, in the heavier type of engineering. In addition, fluency in both written and spoken German is essential and, with this in mind, consideration will be given to foreign nationals possessing this facility, provided their command of English is adequate. Applicants should be under 36 years of age and must be prepared to travel abroad if required.—Write for application form to Personnel Manager, Imperial Smelting Corporation Limited, St. Andrew's Road, Avonmouth, Bristol, quoting ref. DG/TE. E7232 A

DESIGN ENGINEER

required by the United Kingdom Atomic Energy Authority, at Dounreay Experimental Reactor Establishment, Thurso, Caithness, Scotland.

The successful candidate will be responsible to a senior engineer for the supervision of a drawing-office section engaged on design of prototype mechanical and chemical plants and on modifications and improvements to existing plant and equipment.

Applicants must have served a recognised engineering apprenticeship and be Corporate Members of a Senior Engineering Institution or equivalent. Appropriate design and managerial experience is necessary.

Salary within range £1345 to £1800, according to qualifications and experience.

Contributory superannuation. Staff housing scheme. Hostel accommodation may be available.

Send postcard for application form, quoting reference D.E.56/J.1, to Personnel Manager, at above address.

Closing date : 21st September, 1959. E7271 A

DESIGNER-DRAUGHTSMAN

Expanding manufacturers of decorated collapsible metal tubes, impact extruders of rigid aluminium containers, require experienced, first class DESIGNER for design of special purpose, semi-automatic production machines and mechanisms for flow-line production. Minimum qualification O.N.C. having served an indentured apprenticeship. Important permanent position—pension scheme. Housing available in New Town.

SALARY UP TO £1200 PER ANNUM according to experience

Reply to : General Works Manager,
FLEXILE METAL COMPANY, LTD.,
Bessemer Drive, Stevenage, Herts. E7294 A

DRAUGHTSMAN required. Experience in mechanical handling plant and structures an advantage. Good prospects.—British Industrial Sand, Ltd., High Street, Godstone, Surrey. E161 A

ENGINEER (about 30 years) required for Consulting Engineers' Office in Manchester ; Engineering degree and/or corporate membership of a major engineering Institution ; varied industrial experience an advantage. Technical investigations and reports in matters where litigation is being considered. —BOX No. E7298, " The Engineer." A

ENGINEER OR SENIOR SCIENTIFIC OFFICER required by the ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, Berks, to take charge of a small section responsible for the design of V.H.F. and U.H.F. oscillators and modulators for F.M. and pulse radio telemetry systems and the theoretical assessment of new systems. The circuit work requires the application of miniature, sub-miniature and rugged electronic techniques. The system assessment requires an appreciation of noise and propagation phenomena and an awareness of the inherent reliability of various circuits and components.

The post will be graded according to the qualifications and experience of the successful candidate. Qualifications required are :

ENGINEER :

A recognised engineering apprenticeship, or equivalent training, and Corporate Membership of a Senior Engineering Institution.

SENIOR SCIENTIFIC OFFICER :

First or Second Class Honours Degree.

Experience of the design and development of miniature and rugged electronic equipment is very desirable.

SALARY : Engineer, £1345 to £1800. Senior Scientific Officer, £1260 to £1475.

Contributory superannuation scheme. A house or substantial assistance with house purchase will become available for married officers living beyond daily travelling distance.

POSTCARDS for application forms to the Senior Recruitment Officer at above address. Please quote ref. 2389/25. E7277 A

EXPERIENCED ALL-ROUND SALES EXECUTIVE, age 40 or over, for Karachi Branch Office of reputable West End company engineers and steel organisation. Public school or good grammar school background, excellent principles, pension scheme. Only smart man with ability, drive and integrity need apply.—BOX No. E2535, " The Engineer." A

EXPERIENCED ENGINEER for a Steel Re-Rolling Mill in India, producing Steel Rods and Bars to the extent of 50,000/75,000 tons a year. Apply.—BOX No. E2534, " The Engineer." A

FOR A LEADING STEEL FOUNDRY IN INDIA, a FOUNDRY MANAGER with extensive experience of Metallurgy, Methods, Costing, Estimating, Sales and Development of new items, should be capable of negotiating at all levels including Government. Can be given charge of the factory including electric furnaces and machine shops. Very good prospects for enterprising experienced executive. Age not less than 45.—BOX No. E7265, " The Engineer." A

HONOURS GRADUATES IN ENGINEERING AND SCIENCE required, for fundamental research on machine tools and manufacturing techniques. Excellent working conditions and prospects. Good commencing salary with annual increments on merit. Superannuation under F.S.S.U.—Applications to the Secretary (R.579), Production Engineering Research Association, Melton Mowbray, Leics. E7231 A

JOHN LAING AND SON, LIMITED

have the following vacancies in their Research and Development Centre, at Boreham Wood, Herts.

MECHANICAL DESIGN DRAUGHTSMEN of H.N.C. standard with good experience in the design of building and civil engineering plant.

These posts are progressive and pensionable. The work is varied and interesting and holds attractive prospects in an expanding field.

Canteen and Sports Club facilities. Five-day week.

Apply in writing, stating age, experience, &c., to Personnel Manager (MDD13), John Laing and Son, Ltd., London, N.W.7. E7316 A

LONDON REPRESENTATIVE required by Companies engaged in the Manufacture of all types of Structural Steelwork, Steel Framed Buildings, Bridges, Fabricated Steelwork and Vessels for the Gas, Oil and Coke Undertakings, Gasholders, Gas Purification Plant and General Engineering Castings. Applicants should have connections with Consultants, Contractors and Nationalised Industries. Established London office. Superannuation scheme.—Apply, giving full details of education, age and previous experience, stating salary required.—BOX No. E2532, " The Engineer." A

MACHINE TOOL DESIGNER DRAUGHTSMAN

required by

MIDGLEY AND SUTCLIFFE, LTD., LEEDS, 10

An unusual opportunity to participate in interesting development work available to a capable man with ideas together with a sound training and technical qualifications appropriate to this type of engineering.

The appointment is permanent and pensionable.—Applications should be made in writing to the Personnel Officer, Geo. Cohen 600 Group, Ltd., Stanningley, Nr. Leeds. E7261 A

MAJOR ORGANISATION REQUIRES :

1. ARCHITECTURAL ASSISTANTS.
2. STRUCTURAL ENGINEERING DESIGN DRAUGHTSMEN.
3. DESIGN and INTERMEDIATE DRAUGHTSMEN experienced in one of the following :—
   (a) Air conditioning.
   (b) Heating and ventilating.
   (c) Plumbing, and
   (d) Sanitation.

Well experienced persons are required immediately for these interesting posts, in London Division. Salaries offered are HIGH. Please reply, with particulars of experience and qualifications, to Managing Director, Ref. X1, BOX No. E7190, " The Engineer." A

RICHARD SUTCLIFFE, LTD. CHIEF SITE ENGINEER

The Company has over the past years been engaged in supplying bulk materials handling equipment to the coal and other industries.

We now invite applications for the post of Chief Site Engineer in the Surface Division.

The person appointed should be 35-45 years of age, with wide experience of steel erection and with workshop experience. He will be responsible for the supervision of the erection and installations on sites, for the preplanning of the erection programme, and for labour relations.

The position calls for a man of strong character with drive and initiative who is resourceful, tactful and firm. He must be completely mobile and willing to spend long periods away from home.

The salary will be dependent upon qualifications and experience. Contributory pension and life assurance scheme, together with many other employee services, will be available.

Applications, giving full details of age, qualification and experience, together with the names and addresses of three referees to whom reference could be made, should be addressed to :—The Personnel Manager, Universal Works, Horbury, Nr. Wakefield. E7280 A

SALES ENGINEER required by Alfred Wiseman and Company, gear manufacturers, to operate from their London office. Must be mechanical engineer with sales experience. Salary, bonus, expenses and car provided.—Send full details of experience, education and present employment, in confidence, to the London Manager, 8, Southampton Row, London, W.C.1. E7308 A

RICHARD SUTCLIFFE, LTD. PROJECT ENGINEER

The Company has over the past years been engaged in supplying bulk materials handling equipment to the coal and other industries.

We now have a vacancy in the Surface Division for a Project Engineer.

Applications are invited from men who are 27-35 years of age, have passed H.N.C. in Mechanical Engineering, and have previous experience in this type of work. The person appointed will be responsible for the preparation of schemes and quotations for dealing with all contract formalities and for customer liaison.

This position calls for a competent engineer with drive and initiative, capable of taking responsibility and of co-operating with other people in seeing a contract through.

The salary will be dependent upon qualifications and experience. Contributory pension and life assurance scheme, together with many other employee services, will be available.

Applications, giving full details of age, qualification and experience, together with the names and addresses of three referees to whom reference could be made, should be addressed to Personnel Manager, Universal Works, Horbury, Nr. Wakefield. E7281 A

SENIOR AND DETAIL DRAUGHTSMEN

required by

HYDRAULIC DIVISION TANGYES, LIMITED

Interesting and progressive work relating to Hydraulic Equipment for Tunnelling Shields, also the design of Forging, Deep Drawing and Moulding Presses, &c. Excellent Pension Scheme available. Five-day week.

Apply, giving full details of qualifications and past employment (in strict confidence) to The Secretary, Tangyes, Ltd., Cornwall Works, Smethwick, Birmingham. E7289 A

SENIOR CRANE DESIGNER required in West Riding, Yorkshire, with sound knowledge of overhead travelling cranes. Interesting and varied work with good prospects. House provided if necessary. Give full details of experience and salary required.—BOX No. E7220, " The Engineer." A

SENIOR DRAUGHTSMAN required for drawing-office section engaged on the application of small diesel engines to marine propulsion. Experience on this type of work is essential and technical qualifications an advantage. This will be a secure and well-paid position with excellent conditions of service.—Apply in writing, giving full details, to the Personnel Manager, PETTERS, LIMITED, Staines, Middlesex. E7337 A

SENIOR PROJECT ENGINEER with exceptional experience in the design and modern development of a range of punching, shearing and guillotine machines. The position offered is permanent, progressive and pensionable. The location is near Manchester. A suitable salary is offered to a man with vision and initiative.—Apply BOX No. E7264, " The Engineer." A

SENIOR SALESMAN required to operate in the Greater London area, dealing with the sale of Overhead Electric Travelling Cranes up to 100-ton capacity. Applicants should have had previous experience in this field and if possible should have had design and manufacturing experience. First-class prospects of advancement, car provided, pension scheme. Applications.—BOX No. E7248, " The Engineer." A

SITE CIVIL ENGINEERS (2) required for project in Kuwait. Preference will be given to those who are Corporate Members of the Institution of Civil Engineers. A good salary will be paid and there is generous home leave on completion of tour. Bachelor accommodation only, minimum age 25. No income tax is payable in Kuwait.—BOX No. E7269, " The Engineer." A

THE INTERNATIONAL SYNTHETIC RUBBER COMPANY, LIMITED

require a

DEPUTY WORKS ENGINEER

Applications are invited from qualified Mechanical Engineers, age 40-50, who have lengthy shop floor experience with ability to organise and administer to get things done.

Experience of chemical plant or refinery process plant where planned maintenance are in operation would be an advantage.

This is a new appointment which offers a permanent and interesting career with opportunity to live in agreeable surroundings.

Excellent terms of employment, including pension scheme.

Write full particulars of age, experience and qualifications to the Personnel Manager of the Company at Hythe, Nr. Southampton. E7322 A

STRUCTURAL STEELWORK DESIGNER/DRAUGHTSMAN required for interesting and varied work on building frameworks, industrial steelwork and mechanical handling plants. Age 25-30. Permanent position, excellent prospects, good salary, five-day week, pension scheme.—Apply, stating qualifications and experience, to (Ref. CW) Robt. Cort and Son, Ltd., Reading Bridge, Reading. E7164 A

TECHNICAL SALES ENGINEER

This vacancy offers a young apprenticed engineer of at least H.N.C. standard an opportunity to gain commercial experience in our Transformer Sales Dept. in work concerned with on-load tap changers.

Apply, giving details of age, experience, education and present salary to Personnel Officer, Fuller Electric, Ltd., Fulbourne Road, London, E.17. E7327 A

TRANSFORMER DESIGNER

With several years' experience in the design of large H.V. Power Transformers.

Apply, giving details of age, qualifications, experience and present salary to : Personnel Officer, Fuller Electric, Ltd., Fulbourne Road, London, E.17. E7315 A

TWO VACANCIES OPEN

1. DRAUGHTSMAN DESIGNER—for jigs, fixtures and special purpose machines.
2. SUPERVISER required, to be responsible for a Small Engineering Department supervising in the construction of special purpose machinery. He will be fully responsible for this small, but growing, department. Must be first-class engineer, good leader of men, and able to take full control. Knowledge of electrical control equipment would be advantage. Suit man about 30 years of age.

Write in the first instance, giving full details of past experience and qualifications, if any, and indicate present salary.

Apply to : Technical and Works Manager,
W. J. MEDDINGS LIMITED,
IPSWICH ROAD,
TRADING ESTATE,
SLOUGH, BUCKS. E2530 A

WADKIN LIMITED OF LEICESTER (Manufacturers of Woodworking Machinery and High Speed Machine Tools) require a young man as ASSISTANT TO WORKS DIRECTOR. Applicants (age 28/35) with first-class technical and general education should possess a good experience of modern machine shop practice and production methods, preferably in the machine tool industry. They should also possess initiative, drive and personality and be capable of day-to-day management of a works employing 600 workpeople. The post offers a good commencing salary with excellent prospects and a contributory pension scheme is in operation.—Applications, which will be treated in the strictest confidence, giving details of experience and salary required, should be addressed to the Works Director, Wadkin Limited, Green Lane Works, Leicester. E7235 A

WANTED, FIRST-CLASS SENIOR DESIGN DRAUGHTSMAN for firm of General Engineers in Bristol. Good knowledge of general engineering, with particular reference to pressure vessels and stainless steel fabrication. This will be a well-paid position for the top-class man.—BOX No. E164, " The Engineer." A

WELL-ESTABLISHED COMPANY in Foundry Plant Trade desires the services of an experienced man to take over management. Excellent prospects, or amalgamation considered. Replies treated in confidence.—BOX No. E2529, " The Engineer." A

WORKS ADMINISTRATION AND MANAGEMENT. Advertisers seek to appoint an experienced man with knowledge of Metal Fabrication (Steel) preferably including Die Drawing and also hot and cold processes. A well paid, permanent post with prospects is contemplated for suitable person. Confidential treatment is assured of applications, which should give fullest details.—BOX No. E7293, " The Engineer." A

WORKS MANAGER.—Firm employing 500/600 require first-class man with thorough knowledge of electric motor manufacture, ¼ to 200 h.p. Attractive remuneration, contributory pension scheme. Outer S.E. London district.—BOX No. E7283, " The Engineer." A

YOUNG ENGINEER required for interesting investigation work in technical department of large engineering firm in mid-Essex. Practical experience in general engineering desirable. Qualifications should include H.N.C. (Mechanical) or equivalent. Working conditions are good and salary will be commensurate with experience. Please apply, giving full details of training, practical experience, previous and present positions and age, to The Personnel Officer, The Hoffmann Manufacturing Co., Ltd., New Street, Chelmsford, Essex. If desired, Saturday morning interviews can be arranged. E7338 A

MECHANICAL ENGINEERS

not afraid of hard work, required, after preliminary training, to work on own initiative on a wide variety of technical problems. Degree or equivalent, plus basic workshop training. Age under 30.

Write personally, giving full details, to :—

The Chief Engineer,
HOPKINSONS, LIMITED,
P.O. Box B.27,
HUDDERSFIELD,
Yorkshire.

E7313 A

Classified Advts. continued on page 140

PUBLIC APPOINTMENTS

GHANA PUBLIC SERVICE COMMISSION

PUBLIC WORKS DEPARTMENT

APPOINTMENTS

Applications are invited for the following vacancies in the Public Works Department :—

SUPERINTENDENT ENGINEER (ROADS) : responsible for Roads Development Projects, including supervision of planning, design and construction of new trunk roads and the realignment and reconstruction of existing roads. Candidates required to co-ordinate work of Resident Engineers and contractors and be responsible for general direction of large road contracts. Must (a) hold a B.Sc. (Eng.) or other recognised Engineering Degree and have gained not less than 15 years' post-graduate professional experience, or (b) being Corporate Members of the Institution of Civil Engineers or the Institution of Municipal Engineers, must have gained not less than 15 years' professional experience after passing Parts I and II of the examination of the Institution ; (c) of the periods of experience described in (a) and (b) above, not less than 5 years must have been spent in a position of responsibility for the administration, organisation, financial control planning, design and construction of main road projects, including bridges and ancillary works ; (d) preference will be given to candidates experienced in the administration of large-scale road contracts under tropical conditions. Salary scale £2160–£2560 p.a.

CHIEF MECHANICAL ENGINEER : responsible for the organisation, administration and financial control of the Mechanical Engineering Branch of the Public Works Department. This involves the overall administration of a large mechanical staff responsible for the repair, maintenance and overhaul of plant, both stationary and mobile, including mechanical road construction and Public Works plant, equipment and transport. Also directly responsible for the operation of an extensive plant hire organisation. Candidates, preferably between the ages of 35 and 45, must (1) (i) possess a recognised University Degree in Mechanical Engineering, or other qualification giving exemption from Parts I and II of the examinations of the Institution of Mechanical Engineers ; or (ii) must have passed Parts I and II of the examinations and have been admitted as a Corporate Member of the Institution of Mechanical Engineers ; and (iii) must have gained not less than 10 years' experience since obtaining the Degree or exempting qualification or passing Parts I and II of the examination of the Institution of Mechanical Engineers. (2) Of the period of experience described in paragraph (1) (iii) above, not less than 5 years must have been spent in a position of responsibility for the administration, organisation and financial control of a large mechanical workshop or section in a major Government Department or commercial undertaking of similar scope. (3) Candidates must have had experience of the maintenance and overhaul of mechanical plant, equipment and transport, particularly of types used for earth-moving, quarrying, road and building construction and of static plant as used for water supply. Salary scale £2280–£2400 p.a.

Appointments on contract/gratuity terms for 3 tours, each of 15–18 months in the first instance. Gratuity at rate of £12 10s. for each completed month of service. Free passages for officer, wife and up to 3 children under 18 years and, in addition, an education allowance for children when not resident in Ghana of £100 a child for up to 3 children under 18 years. Accommodation at low rental. Interest-free advance for car and car maintenance allowance. Generous home leave on full pay. Income tax at low local rates.

For further particulars and application forms write, stating age, qualifications and experience, to The Director of Recruitment, Ghana High Commissioner's Office, 13, Belgrave Square, London, S.W.1. E7275

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

WATER POLLUTION RESEARCH LABORATORY, STEVENAGE, HERTS

ASSISTANT EXPERIMENTAL OFFICER (MECHANICAL ENGINEER)

D.S.I.R. requires ASSISTANT EXPERIMENTAL OFFICER (MECHANICAL ENGINEER) at Water Pollution Research Laboratory, Stevenage, Herts, to prepare drawings and assist in designing, testing and developing experimental apparatus. Qualifications : G.C.E. (A level) in a Mathematical and Science subject ; over 22 Pass Degree, H.N.C. in Mechanical Engineering or equivalent generally expected. Drawing-office training and workshop experience essential. Salary (men), £382 10s. to £830. Housing facilities available.—Forms from M.L.N.S. Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting C 595/9A. Closing date, 15th October, 1959. E7314

WEY VALLEY WATER COMPANY

CIVIL ENGINEERING ASSISTANT

CIVIL ENGINEERING ASSISTANT, commencing salary £750–£850 per annum, with annual increments, plus car allowance.

Applications are invited for the above appointment on the permanent staff of the Wey Valley Water Company.

Qualifications : applicants must have been trained as civil engineers and have either passed Parts I and II of the Institution of Civil Engineers' examination or hold a University Degree. Preference will be given to those who have had experience in the office of a water engineer.

The applicant should hold a licence to drive a car.

The appointment is permanent and pensionable.

Applications, stating age, qualifications, present position and salary, and giving an account of his education, training and experience, should be sent to the Engineer and Works' Manager, Wey Valley Water Company, 3, Downing Street, Farnham, Surrey, not later than 30th September, 1959. E7243

PUBLIC APPOINTMENTS

ROYAL NAVAL SCIENTIFIC SERVICE

SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS

Vacancies for SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS in following localities :

LONDON AREA : MECHANICAL ENGINEER with sound knowledge of basic principles of thermo and fluid dynamics to carry out research programme in a particular field of applied hydrodynamics. Experience in modern methods of design and research on axial flow compressors, turbines or pumps an advantage. MECHANICAL ENGINEER for work on propulsion problems. APPLIED MATHEMATICIAN for research of basic nature on stability of underwater vehicles : knowledge of theoretical hydrodynamics and theory of control systems an advantage. APPLIED MATHEMATICIAN or THEORETICAL PHYSICISTS for acoustic analysis. ELECTRONIC PHYSICISTS for data handling and analysis problems. PHYSICIST interested in operator performance. CLASSICAL PHYSICISTS.

BALDOCK : PHYSICISTS or APPLIED MATHEMATICIANS for research in Metal or Quantum Physics.

PORTSMOUTH : ELECTRONIC ENGINEERS for research on analogue computers and transistor circuits. ELECTRICAL ENGINEERS for research on small rotating electrical machinery. PHYSICISTS—for optical systems and instrumentation. ELECTRO-MECHANICAL ENGINEERS — for work on servo-mechanisms.

PORTLAND : PHYSICISTS or APPLIED MATHEMATICIANS for research on underwater acoustics. ELECTRONIC PHYSICISTS, ELECTRONIC ENGINEERS—for design work. PHYSICAL CHEMISTS.

POOLE : CHEMICAL ENGINEERS. CHEMISTS for work on rubber technology.

ROSYTH : PHYSICISTS—(Electronic).

Candidates must normally be natural born British subjects of natural born British parents, with First or Second Class Hons. Degrees, S.S.Os. must have had three years' post-graduate experience and be not less than 26 years of age. Salaries (men) : S.S.O., £1233–£1460 ; S.O., £655–£1150 (London), somewhat lower in provinces. Appointments unestablished (with F.S.S.U. benefits), but opportunities may occur for those between ages of 21 and 32 to compete for established posts.

Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1 (quote A.220/9A). E7037

ST. DAVID'S HOSPITAL, CARMARTHEN

ASSISTANT ENGINEER

ASSISTANT ENGINEER required at St. David's Hospital, Carmarthen (1016 beds).

Applicants must have served a recognised engineering apprenticeship and have a sound knowledge and experience of steam boiler plants and auxiliaries, heating and domestic hot water apparatus and electric installations.

Candidates should possess the Ordinary Engineering Certificate in Mechanical Engineering (including heat engines and the principles of electricity), or an equivalent qualification.

Salary and conditions of service for this post, which is superannuable, will be in accordance with the Whitley Council recommendations, £605 by £25 (3) by £30 (2) to £740 per annum.

The successful candidate will be required to reside near the hospital. Unfurnished flat available.

Applications, giving details of age, qualifications and experience, and quoting the names and addresses of three referees who can testify to professional ability, should be forwarded to the Secretary, St. David's Hospital, Carmarthen, by September 25th. E7216

ROYAL NATIONAL ORTHOPÆDIC HOSPITAL, 234, GREAT PORTLAND STREET, LONDON, W.1

ASSISTANT ENGINEER

ASSISTANT ENGINEER required to assist the Superintendent Engineer in the supervision of the engineering services of this teaching hospital. Applicants must have completed an apprenticeship in mechanical engineering or have otherwise acquired a sound practical training in mechanical engineering. Salary and conditions of service in accordance with the appropriate Whitley Council terms and conditions. Salary scale £545–£670 p.a., plus £30 London weighting allowance for officers over 26 years of age. A starting salary up to two increments above the minimum may be awarded in respect of relevant experience since the completion of practical training. —Applications, in writing, giving details of age, previous experience and the names and addresses of two referees, should be addressed to reach the House Governor and Secretary at the above address by not later than 29th September, 1959. E7336

BOARD OF GOVERNORS, HAMMERSMITH AND ST. MARK'S HOSPITALS, DU CANE ROAD, LONDON, W.12

ENGINEERING TECHNICAL ASSISTANT

ENGINEERING TECHNICAL ASSISTANT required. Salary scale (under review) £725 by £20 (4) by £25 (2) to £855, plus London allowance £20 to £40.—Further particulars from Secretary. E7273

PUBLIC APPOINTMENTS

H.M. INSPECTOR OF FACTORIES

Pensionable career posts in Ministry of Labour and National Service for men and women, normally with science or arts degree or comparable technical qualification, and preferably some industrial experience. Age at least 23 and under 30 on 1st June, 1959 (with extension for regular Forces service, Oversea Civil Service or exceptional qualifications). The duties are concerned with the safety, health and welfare of workers in industry. Starting salary (London) £670–£772 according to age. Scale maximum £1065. Promotion prospects to £2000 and higher.—Write Civil Service Commission, Burlington Gardens, London, W.1, quoting 280/3. E7301

TENDERS

NOTICE TO CIVIL ENGINEERING CONTRACTORS

REPUBLIC OF PAKISTAN

MANGLA DAM PROJECT

The West Pakistan Water and Power Development Authority expect to issue tender documents before the end of 1959 for the construction of Mangla Dam, an earth-fill embankment some 350ft in height, 14,000ft. long and containing approximately 70 million cubic yards of embankment material.

Civil Engineering Contractors interested in tendering for this contract are invited to apply at once for a Summarised Description of the Works either to :

The Chief Engineer, Mangla Dam Project, P.O. Mangla Headworks, District Jhelum, West Pakistan or to the Consulting Engineers, Messrs. Binnie, Deacon and Gourley, Artillery House, Artillery Row, London, S.W.1, England.

Contractors who, after studying the Summarised Description, wish to be placed on the list of Tenderers should send an application, in English, to the Consulting Engineers, giving details of their resources, and of their experience in large-scale earth-fill dam construction, including the value and description of works which they have carried out, time of construction, and the names of the employers and consulting engineers responsible.

Applications to be placed on the list of Tenderers must reach the Consulting Engineers not later than 19th October, 1959. Those firms considered to have sufficient experience and resources will be sent the Tender documents in due course. E7297

SCOTTISH HOME DEPARTMENT COUNTY OF ARGYLL

TARBET-INVERARAY-LOCHGILPHEAD-OBAN TRUNK ROAD A.83

CONTRACT A.2A

The Secretary of State invites TENDERS for the COMPLETION of the RECONSTRUCTION of the above TRUNK ROAD at Loin Bridge and Black Spout—a total of approximately 3·6 miles of new or reconstructed road, including some work for the Post Office.

Contract documents and further information obtainable from the Chief Road Engineer, Scottish Home Department, Bankhead Avenue, Sighthill, Edinburgh 11, upon payment of a deposit of £10 by cheque or draft, made payable to the Queen's and Lord Treasurer's Remembrancer. Deposit will be refunded if a bona-fide Tender is submitted and not subsequently withdrawn.

Drawings may be inspected at the offices of the Scottish Home Department (Roads Division), Glenshellach Road, Oban, 33, Academy Street, Inverness, and Bankhead Avenue, Sighthill, Edinburgh 11.

Tenders on the official form which must be received before 4 p.m. on Thursday, 8th October, 1959, should be sent in a sealed, registered envelope marked "Tender for Road Works Contract No. A.2A," to the Secretary, Scottish Home Department, Broomhouse Drive, Saughton, Edinburgh, 11.

The Secretary of State does not bind himself to accept the lowest or any Tender. E7305

INDIA STORE DEPARTMENT

The Director General of India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of :

	Quantity, lb.
NICKEL RODS and STRIP, cold drawn, for the manufacture of Gears and Pinions of water meters.	17,000 approx.

Forms of Tender may be obtained from the above address on or after the 11th September, 1959, at a fee of 10s., which is not returnable. If payment is made by cheque, it should please be made payable to "High Commissioner for India." Tenders are to be delivered by 2 p.m. on Thursday, 22nd October, 1959. Please quote reference No. 18/59/RLY. E7328

TENDERS

LEE CONSERVANCY CATCHMENT BOARD

FLOOD ALLEVIATION SCHEME

CONTRACT NO. 14

TENDERS are invited for the following WORKS in the Borough of Walthamstow, in the County of Essex :—

(a) Construction of :

(i) A Prestressed Concrete Aqueduct Bridge, of 20ft. width and 75ft. single span, founded upon bored piles.

(ii) A Prestressed Concrete Access Bridge, of 14ft. width and 65ft. single span, founded upon bored piles.

(iii) A Reinforced Concrete Inverted Syphon, of 72in. internal diameter and of 200ft. total length.

(iv) A Reinforced and Mass Concrete Open Flood Channel, of 630ft. length and about 52ft. in width.

(b) Demolition, Filling, Soiling, Seeding, Fencing and other Appurtenant Works.

Instructions to Tenderers, documents and site plan are obtainable from N. Medrington, Esq. A.M.I.C.E., M.I.W.E., Engineer to the Board, at "The Grange," Crossbrook Street, Cheshunt, Herts (telephone : Waltham Cross 24211), on payment of £5, returnable under certain conditions. Documents and detail drawings may be inspected without payment at the Engineer's Office. Copies of detail drawings may be obtained on loan. Tenders are to be delivered to the undersigned before 12 o'clock noon on the 12th October, 1959.

J. L. SPILLER,
Clerk of the Board.

The Lee Conservancy Catchment Board,
Brettenham House,
Lancaster Place,
Strand, W.C.2. E7292

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 F

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A LEADING MANUFACTURER OF HYDRAULIC EQUIPMENT for the Industrial and Aircraft Industries, requires an ENGINEER to take responsibility for the technical aspects of all its rubber and plastic components. Applicants must have a detailed knowledge of the physical and chemical properties of these materials, and have some experience in the design of components manufactured from them.—Applications, giving full details of age, experience, &c., to BOX No. E7326, "The Engineer." A

AN EXPERIENCED TIME STUDY ENGINEER is required to supervise the setting of up-to-date standards in a medium-sized factory situated in the North-West of England, engaged in the production of special machinery. The company, which is a progressive one, enjoys a high reputation throughout the world and the position advertised provides excellent scope for ultimate appointment as head of the department. Please give full details of age, training, experience to date, present salary, &c.—BOX No. E7278, "The Engineer." A

AIR TREATMENT ENGINEER required for group of mills near Manchester. Applicants should be capable of preparing schemes and estimates for new plants, and supervising erection and maintenance. Please state experience, technical qualifications and age.—BOX No. E7311, "The Engineer." A

ASSISTANT CHIEF ENGINEER

required by old-established Company manufacturing heavy cranes and allied equipment. Salary £1850. Pension. Applicants must have worked for two or three unrelated companies, including four years on cranes, have served a workshop and drawing-office apprenticeship, have A.M.I.Mech.E. or Degree and be between 32 and 42 years of age. The Chief Engineer will open all applications and treat them as strictly confidential.—BOX No. E2527, "The Engineer."

A

COMPETENT DRAUGHTSMAN, conversant with quarry plants, sound knowledge of structural steelwork. Interesting and varied work, opportunity for site visits, &c.—Roads Reconstruction (1934), Ltd., Engineering Department, Cranmore, Nr. Shepton Mallet, Somerset. E2536 A

DAVY AND UNITED ENGINEERING COMPANY, LIMITED, Britain's largest organisation of rolling mill and auxiliary plant manufacturers, invite applications from ambitious qualified men interested in heavy engineering for positions as PROJECT ENGINEERS. Successful applicants would have experience of steel and non-ferrous rolling mills of all types and will be responsible for engineering machinery prior to tendering. Items range from individual units to complete rolling mill plants. All contracts, irrespective of size, have to be individually engineered, offering a wide range of interest and unlimited scope for ingenuity and initiative. Excellent working conditions in modern building. Dining facilities, contributory pension scheme.—Apply in writing with details of age, experience, qualifications, &c., to Personnel Department, Davy and United Engineering Co., Ltd., Darnall Works, Sheffield, 9. E7307 A

SITUATIONS VACANT

THE GLACIER METAL COMPANY LIMITED

Invites applications from

YOUNG ENGINEERS

for posts in a

SPECIAL ASSIGNMENT GROUP

attached to the Chief Production Engineer at Company Headquarters. On entering, they will be deployed to work on special projects chosen to allow them to make an immediate impact on the work of the Company. Projects are of great interest and often concern new developments ; they last some months each and may take place in any of the Company's Factories in England or Scotland. After up to eighteen months in the Group members are eligible for permanent positions in the Company where career prospects are excellent.

Salary Range : £950–£1350 per annum. Qualifications : a good degree, the completion of an apprenticeship and preferably (though not essentially) some practical experience.

Applications should be sent to

Personnel Director (Ref. SA),
GLACIER METAL CO., LTD.,
Ealing Road, Alperton, Wembley, Middx.

E7321 A

SITUATIONS VACANT

REQUIRED BY MAJOR AUTOMOBILE MANUFACTURERS IN THE MIDLANDS

PRODUCTION PLANNING ENGINEER

aged 35-40. Salary £2000-£2500 offered for a man with the following qualifications, University Graduate or Member of the Institute of Mechanical Engineers/Production Engineers. Must be fully trained engineer with sound experience in mass production methods preferably in the automobile industry in the United Kingdom, U.S.A. and the Continent of Europe. Should be able to put over new projects with management and work people with the minimum of friction.

Write giving age and full details of past experience and when available, in confidence, to Box TE.164, c/o 191, Gresham House, London, E.C.2.

E7324 A

SITUATIONS VACANT

PORTASILO

SENIOR DESIGN DRAUGHTSMAN

The leading United Kingdom manufacturers of portable bulk handling and storage equipment invite applications from Draughtsmen, not over 38 years of age, experienced in the design of light and medium mechanical engineering products, for a vacancy in their Design Office at York.

The work is of a varied and interesting nature, and applicants must be responsible men of good calibre, capable of taking charge of a design project from initial conception to the testing and development of prototypes for production.

This permanent position offers excellent staff conditions, above average commencing salary and good prospects, biannual bonus and non - contributory pension scheme. Residence in or near York is essential and assistance will be given with removal expenses and house purchase.

Written applications in confidence, stating age, full details of training and experience, and some indication of salary required, should be addressed for the personal attention of :

Managing Director,
PORTASILO, Limited,
Blue Bridge Lane, York.

E7335 A

SITUATIONS VACANT

GHANA

An important mining concern in Ghana wishes to appoint a

CHIEF ENGINEER

Applicants should be members of a recognised professional Engineering Institution and be between the ages of 35 and 45.

Salary in the range £2500–£3000. Leave on full pay at the rate of 3 months after 15 months' service, with passages paid. Free passages for wife ; free furnished quarters ; car provided for use on the property ; and certain other benefits. Local Income Tax rates. The post is permanent and pensionable.

Please write, giving essential details, to BOX No. E7331, " The Engineer." A

CENTRAL ELECTRICITY GENERATING BOARD

RESEARCH AND DEVELOPMENT DEPARTMENT

Applications are invited for the following appointments in the CHEMISTRY AND METALLURGY SECTION of the RESEARCH LABORATORIES, LEATHERHEAD, SURREY :—

(a) METALLURGIST, to work on problems associated with fuels and canning materials for nuclear power stations. Candidates must have an Honours Degree or equivalent qualification in Metallurgy ; experience in physical metallurgy is desirable.

(b) METALLURGIST or ENGINEER, to carry out investigations involving high-temperature creep and tensile testing of metals used in conventional and nuclear power stations. Candidates must at least hold H.N.C. in Metallurgy or Engineering ; experience in creep and mechanical testing would be an advantage, but applicants without this experience will be considered.

Salaries will be on scales within a range rising to £1300 p.a., according to duties and responsibilities.

Applications stating age, qualifications, experience, present position and salary should be forwarded to the Personnel Officer, 24/30, Holborn, London, E.C.1, by 26th September. Envelopes should be marked " Confidential Ref. ENR 356."

E7325 A

THE BAHRAIN PETROLEUM COMPANY LIMITED

GRADUATE METALLURGISTS AND MECHANICAL ENGINEERS

are required in Bahrain's modern Oil Refinery for plant and corrosion inspection work. Applicants, under 35, should be familiar with A.P.I., A.S.M.E. codes and have had a minimum of two years' experience in similar work or in the construction and maintenance of fired and unfired pressure vessels, the duties including inspection of vessels, exchangers, pumps, lines, valves, &c., to ensure safe operating condition and the recommending and developing of materials and methods of repair and corrosion control.

Salary would be in accordance with qualifications and experience, but not less than £1332 per annum, in addition to which free air-conditioned accommodation and a living allowance are provided. An initial kit allowance, medical attention, paid home and local leaves, are also provided, passage paid for the former and generous assistance towards the fare for the latter.

Apply in writing, quoting " INS " with full particulars., to Caltex Services Limited, Caltex House, Knightsbridge Green, London, S.W.1.

E7339 A

THE BAHRAIN PETROLEUM COMPANY LIMITED

Require a

MAINTENANCE ENGINEER

This post is open to recent Graduates in Mechanical Engineering, under 28 years of age, who are interested in all phases of planned maintenance of heavy plant and who have preferably some experience on pressure vessel, heat exchanger and pump repair or construction. It is intended that the selected candidate should train in Bahrain with a view to advancement to at least Area Engineer in the large and modern refinery there.

A good salary can be offered, dependent on qualification, in addition to which free air-conditioned accommodation and a living allowance are provided. An initial kit allowance, medical attention, paid home and local leaves are also provided, passage paid for the former and generous assistance towards the fare for the latter.

Apply in writing, quoting " MTC," with full particulars, to : Caltex Services Limited, Caltex House, Knightsbridge Green, London, S.W.1.

E7340 A

STEAM TURBINE DESIGN ENGINEER

Several vacancies exist at Pametrada Research Station for DESIGN ENGINEERS who are interested in marine propulsion. The work is of an advanced nature and a great variety of problems are dealt with, including aerodynamic design and stressing, vibrations, heat balances, &c. Applicants should have a good Engineering degree or equivalent qualification. Some knowledge of marine work will be an advantage. Starting salary will range from £1000 to £1500, depending on age, qualifications and experience. Staff Pensions Scheme and good working conditions. Apply in confidence to the Director, Pametrada Research Station, Wallsend, Northumberland.

E7342 A

TECHNICAL SALES REPRESENTATIVE

Applications are invited for the post of Technical Sales Representative with a leading firm of pipeline valve manufacturers.

Applicants should be between the ages of 27 and 35 and have a good engineering background. Previous sales experience is very desirable ; initiative, a good personality and the ability to work without direct supervision are essential. This is a responsible position and the successful applicant would represent the Company in Scotland and Northern Ireland.

Remuneration would be by salary and expenses and a Company car would be provided.

The Company offers first-class conditions of employment and housing assistance would be given if necessary.

Applications, giving details of age, qualifications, experience and salary required, should be sent to :—

Sales Manager,
Audley Engineering Company Limited,
Newport,
Shropshire.

E7332 A

SITUATIONS WANTED

CHARTERED MECHANICAL ENGINEER seeks appointment requiring original thought. In addition to executive duties experience includes design and development both in this country and on the Continent.—BOX No. E2526, " The Engineer." B

YOUNG SWISS EXPERIENCED TOOLMAKER wishes to find work in England. Could begin anytime.—BOX No. E2537, " The Engineer." B

PATENTS

THE PROPRIETOR of British Patent No. 751550, entitled " IMPROVED PILOT BIT FOR AN EARTH BORING AUGER," offers same for Licence or otherwise to ensure practical working in Great Britain.—Inquiries to Singer, Stern and Carlberg, 14, E. Jackson Blvd., Chicago 4, Illinois, U.S.A. E7237 H

THE PROPRIETOR of British Patent No. 709968, entitled " LASHING MACHINE FOR AERIAL CABLES," offers same for Licence or otherwise, to ensure practical working in Great Britain.—Inquiries to Singer, Stern and Carlberg, 14 E. Jackson Blvd., Chicago, 4, Illinois, U.S.A. E7236 H

THE PROPRIETOR of British Patents Nos. 711112 and 751139, entitled " IMPROVEMENTS RELATING TO THE CONDITIONING OF THE EXHAUST GASES OF INTERNAL COMBUSTION ENGINES " and " EXHAUST GAS PURIFIER," offers same for License or otherwise, to ensure practical working in Great Britain.—Enquiries to Singer, Stern and Carlberg, 14 E. Jackson Blvd., Chicago, 4, Illinois, U.S.A. E7252 H

THE PROPRIETORS of British Patent No. 758,519, for " AN IMPROVED MULTI-STAGE SELF-PRIMING CENTRIFUGAL PUMP," desire to enter into negotiations with a firm or firms for the Sale of the Patent or for the grant of Licences thereunder.—Further particulars may be obtained from Marks and Clerk, 57 and 58, Lincoln's Inn Fields, London, W.C.2. E7323 H

BUSINESSES and PREMISES

VICTORIA. In a First Class Building and address, First Floor Offices suitable for Consulting Engineers or Architects. Large Drawing-Office, 3 Private Offices, Central Heating nearly 1400 square feet. 5 years' lease.—Apply : Whatley, Hill and Company, 24, Ryder Street, S.W.1. WHItehall 4511. E7290 L

POYLE TRADING ESTATE, COLNBROOK, BUCKS.

MODERN FREEHOLD FACTORY FOR SALE. SITE AREA 11,000 sq. ft. MAIN BDG. INCLUDING OFFICES ON ONE FLOOR 3300 SQ. FT., SMALLER BDG. 900 SQ. FT. BOTH BRICK WITH ASBESTOS ROOFS. PLANS APPROVED FOR EXPANSION. PRICE £15,500. Apply SOLE AGENTS.

WM. PEARSON & CO.,
SURVEYORS,
10, STRATTON ST., W.1.
GRO. 2269. E2533 L

MISCELLANEOUS

MOBILE LIFTING SERVICES.—Lump Sum or Hire Rate Quoted for any Lifting Work by Lorry-Mounted or Crawler Cranes, any size, any area.—TARSLAG, LTD., Rotherham 3235. E7215 I

TIME RECORDERS. Sales, Rentals, Service, Telephone Hop 2239.—Time Recorder Supply and Maintenance Co., Ltd., 157–159, Borough High Street, London, S.E.1. E110 I

Classified Advts. continued on page 142

BUSINESS OPPORTUNITIES

REMPLOY SPONSORSHIP SCHEME.—Send for details which show an attractive proposition to manufacturers.—Write to the Managing Director, Remploy, Ltd., 25-28, Buckingham Gate, S.W.1, or telephone VICtoria 6621 (12 lines). E155 o

ADVERTISER, PRIVATE INVESTOR desires to purchase whole or part interest in concern under progressive management making annual net profit of £15/50,000.—BOX No. E163, "The Engineer." o

TO ENGINEERING GROUPS.—Ultra Modern Foundry producing HIGH-GRADE GREY IRON CASTINGS, capacity 200 tons weekly. Would consider amalgamation and/or co-operation. Asset value of freeholds and plant approximately £150,000/£200,000.—BOX No. E165, "The Engineer." o

SUB-CONTRACTING

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process; sample castings treated; A.I.D. approved.—Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E109 MW

KELLERING AND CAM PROFILING capacity up to 8ft. by 6ft. or 6ft. diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone: Knottingley 2743/4). E116 MW

PRATCHITT BROTHERS, LTD., Denton Iron Works, Carlisle, having well-equipped engineering shops and ironfoundry, invite enquiries for General Engineering, Structural and Platework, from firms wishing to have plant made to their own designs and specifications. E751 MW

CENTRE LATHES:
Up to 14ft. 0in. dia. by 44ft. 0in. long.
VERTICAL BORING:
Up to 15ft. 7in. dia. by 8ft. 0in. high.
HORIZONTAL BORING:
Up to 8in. spindle, 40ft. 0in. by 20ft. 0in. table.
PLANING:
Up to 34ft. 0in. long by 11ft. 11in. wide by 8ft. 0in. high.
PLANO MILL:
Up to 14ft. 0in. long by 6ft. 6in. wide by 5ft. 6in. high.
SHAFT GRINDING:
Up to 23ft. 0in. long by 2ft. 0in. dia.
SLIDEWAY GRINDING:
Up to 7ft. 0in. long by 4ft. 0in. high by 2ft. 0in. wide.
VERTICAL SPINDLE GRINDING:
Up to 11ft. 0in. long by 1ft. 9in. high by 2ft. 0in. wide.

HARVEY

G. A. HARVEY & CO. (LONDON) LTD., WOOLWICH ROAD, LONDON, S.E.7.

E7256 MW

FOR HIRE

BELLMANS MASTS FOR HIRE, to lift from 1 to 20 tons, 30ft. to 150ft. Blocks and tackle. Hand-operated winches. From £1 per day.—BELLMAN'S (Phone: SLOane 5259), Hobart House, Grosvenor Place, S.W.1. E103 K

MACHINERY Etc. WANTED

TWO 12,000 LB. HR. ECONOMIC BOILERS, 160/200 p.s.i. Must be modern 2 or 3-pass considered.—BOX No. E7287, "The Engineer." F

TWO SINGLE FLUE ECONOMIC BOILERS, suitable for oil-firing, 6000/8000 lb./hr., 120/160 p.s.i. Paxman Ultranomic preferred, but will consider others.—BOX No. E7288, "The Engineer." F

BALL AND ROLLER BEARINGS, &c., WANTED. Also SURPLUS GOODS.—especially Hand Tools—of all descriptions.—R. Pordes, 138, New Cavendish Street, London, W.1 (MUseum 5250). E7330 F

WANTED IMMEDIATELY.—COLD DRAWN MILD STEEL TUBE.
45 lengths 4in. o/d. by 3¼in. i/d. by 6ft. 11in.
22 lengths 4in. o/d. by 3¼in. i/d. by 6ft. 6in.
1 length 4¼in. o/d. by 4in. i/d. by 6ft.
'Phone: MAIn (Oldham) 5248. E2531 F

FOR SALE

HYDRAULIC FORMING AND FORGING PRESSES

3000-ton Down-stroke PRESS for HEAVY PLATE FORMING AND BENDING, rams; admitting 10ft. 6in. between columns; bed 16ft by 8ft..
2000-ton Down-stroke FORGING PRESS, 5ft. stroke; bed 8ft. 6in. by 8ft.; daylight 11ft.
1000-ton Down-stroke FORGING PRESS by Wellman, bed 7ft. by 6ft.; daylight 9ft.
475-ton FLANGING PRESS by Hugh Smith, table 10ft. dia., 4 vice rams.

REED BROTHERS (ENGINEERING), LTD.,
Replant Works,
Woolwich Industrial Estate,
London, S.E.18.
Telephone: Woolwich 7611/6.
E7184 G

FOR SALE

RICKMANSWORTH AND UXBRIDGE VALLEY WATER COMPANY

REDUNDANT PLANT FOR DISPOSAL

Offers are invited for the undermentioned redundant PLANT which the Company has for DISPOSAL:—
(1) ONE LANCASHIRE BOILER, 7ft. 6in. by 30ft., with superheater. 150 lb. pressure, by H. and T. Danks, 1930; also Bennis Stoker and Airdraught Furnace.
(2) ONE DITTO, 8ft. by 30ft., with superheater. 150 lb. pressure, by Edwin Danks, 1933, with Bennis Stoker and Airdraught Furnace.
(3) TWO STEAM BOILER FEED PUMPS and WATER TREATMENT PLANT.
(4) BELLISS and MORCOM TRIPLE EXPANSION STEAM ENGINE coupled 180kW., 220V., D.C. Generator and Condensing Plant.
(5) BROWETT LINDLEY 300 B.H.P. COMPOUND VERTICAL STEAM ENGINE and CONDENSING PLANT.
(6) BELLISS and MORCOM COMPOUND STEAM ENGINE, 200 B.H.P., 380 R.P.M., with Condenser and "V" drive Pulley.
(7) D.C. VOLTAGE BOOSTER, 50 B.H.P., 500A. by 65V. by 230V. input.
(8) GREENWOOD and BATLEY STEAM TURBINE and Gearing, 150 B.H.P. at 1500 R.P.M., with Atmospheric Condenser.
(9) BELLISS and MORCOM STEAM TURBINE GENERATING SET, 500kW., 220V., D.C., with condensing plant. Excellent condition.

The plant may be inspected by appointment being made with the Chief Engineer at the Head Office of the Company, Batchworth, Rickmansworth, Herts. Telephone No.: Rickmansworth 3122. E7266 G

MODERN AIR COMPRESSORS MOTORISED, 400 VOLT, 3-PHASE 50 CYCLES
100 LB. WORKING PRESSURE

One 540 c.f.m. INGERSOLL RAND type XVH 2-stage with 105 h.p. Slip Ring Motor, completely reconditioned and rebuilt.
Two 495 c.f.m. BROOM AND WADE type EH251 single-stage with 112 h.p. Slip Ring Motors. New 1951. First-class condition.
One 330 c.f.m. BROOM AND WADE type EH241 single-stage with 75 h.p. Slip Ring Motor. New 1951. First-class condition.
Two 300 c.f.m. ALLEY AND MACLELLAN series 23B Size No. 4. 2-stage with 67½ h.p. Slip Ring Motors. New 1951. First class condition.
Three 315 c.f.m. C.P.T. type PB4 air-cooled 2-stage with 85 h.p. Slip Ring Motors and vertical receivers 6ft. by 3ft. diameter. All on bed-plates.
Three 470 c.f.m. "REAVELL" size VS1/6 single-stage double-acting, 40 lb. pressure, with 50 h.p. Mather and Platt motors. New 1950. Almost as new.
One 65 c.f.m. REAVELL type DSA7E, single-stage, 135 lb. pressure, with 21 h.p. Mather and Platt Motor. New 1950. Almost as new.

ATTRACTIVE PRICES—IMMEDIATE DELIVERY

G. E. SIMM (MACHINERY), LIMITED,
27, Broomgrove Road, Sheffield, 10.
E7282 G

FOR SALE

6-ton capacity, All-Electric RADIAL TRAVELLING CABLEWAY, by J. M. Henderson, span 1220ft., head mast height 120ft., tail mast height 17ft., with electric travel over arc of 70 deg., operating depth 250ft. Available after Sept., 1959.
One ROTARY SCREEN, by J. and F. Pool, complete with screening surfaces, approx. 30 tons per hour, 8ft. 6in. dia. by 24ft. 6in. in length. Price £350.
One Ruston and Hornsby, 3ft. 1½in. gauge, 44/48 h.p. Diesel Engine, good condition, Serial No. 203035. Price £125 or nearest offer.
Six Decauville 5-ton Side Tipping WAGONS, 3ft. 1¼in. gauge. Price £15 each.
One Ruston 4VRO ENGINE, No. 234896, suitable for 19RB Excavator. Price £300.
All the above plant may be inspected at our Croft Works.
Apply: THE CROFT GRANITE, BRICK AND CONCRETE CO., LTD., Croft, Leicestershire. E159 G

FRED WATKINS (ENGINEERING) LTD.

Fielding 500-ton Vertical Downstroke Hydraulic Press, 42in. by 36in. platens, with pumps and motors.
Fielding 200-ton, di to, 3ft. stroke, with pumps and motors (5 availab e).
Fielding 100-ton ditto, 4ft. to 5ft. stroke, with pumps and motors.
Two 73ft. 4in. by 5ft. Kilns or Dryers, with Crofts Reduction Gear and 27 h.p. motor.
Two 26ft. by 4ft. Rotary Cooler or Dryers, with reduction gear and motor.
Available at low prices ex present sites to save cost of bringing into stock.

FRED WATKINS (ENGINEERING), LTD., COLEFORD, GLOS. E151 G

FOR SALE

6-ton Ransomes and Rapier Standard and Super pet./elec. Mobile Cranes (diesel conversion available).
5-ton Morris Versatile diesel elec. Mobile Crane on solid rubber tyres.
1-ton Rapier pet./elec. Shop Truck Crane on solid tyres.
Several Murex 300/400 amp. Welding Sets powered by Perkins, P4 diesel engines.

WILLIAM G. SEARCH, LIMITED,
WHITEHALL ROAD, LEEDS, 12.
Tel.: 639081 10 lines).
SEARCH (LIVERPOOL), LIMITED,
HAMMOND ROAD, KIRKBY TRADING ESTATE, LIVERPOOL.
Tel.: Simonswood 3361 (5 lines).
E7312 G

FOR SALE

FRED WATKINS (ENGINEERING) LTD.

STEAM BOILERS.—Cochrane Vertical (New), 8ft. 6in., 8ft., 7ft. 6in., 7ft. and 6ft. in dia. 100/150 lb. w.p.; reconditioned 8ft. 6in. down to 3ft. dia.; Economic 4ft. to 11ft. 6in. dia., including new 7ft. and 8ft. dia., 150, 180 and 200 lb. w.p., 300 reconditioned Vertical Crosstube, all sizes.
AIR COMPRESSORS.—Two Belliss & Morcom 2500 c.f.m., 100 p.s.i., 550 h.p. motors; also Broomwade 500, 400, 300, 200 and 130 c.f.m., all motorised; and several others of various makes and capacities.
200 AIR RECEIVERS, stocked up to 9ft. dia., 100 to 500 lb. pressure.
ELECTRIC MOTORS.—150 Totally Enclosed and Flameproof Motors up to 200 h.p.
MOBILE ROAD CRANES.—10-ton Lorain lorry mounted 30ft.–70ft. extendible jib; 10-ton 33 R.B. track mounted, 40ft. jib; 8½-ton Ransomes Diesel/Electric, 21ft. jib; 6-ton Coles Diesel/Electric, pneumatics, new 1948 (2); 6-ton Coles Diesel/Electric, solids; 4-ton Coles Diesel/Electric, solids; 1945; 4-ton Jones KL44, diesel, 1950; 3-ton Jones "Super 40" diesel, pneumatics (3).
OVERHEAD CRANES.—40-ton Babcock, 40ft. span, 400/3/50, "Goliath"; 30/5-ton Adamson, 42ft. 3in. span, 400/3/50; 20/6-ton Vaughan, 42ft. 3in. span, cab type (6); 20-ton King, 42ft. 3in. span, 400/3/50; 15-ton Morris, 35ft. span, hand-operated; 10-ton Morris, 45ft. span, 36ft. lift; 10-ton Morris "Goliath," 40ft. span, 400/3/50; 10-ton Vaughan, 23ft. 6in. span, 400/3/50; 10-ton Vaughan, 21ft. span, 44ft. lift, 7½ tons; Wharton, 25ft. span, 400/3/50; 5-ton Henderson, 24ft. 7in. span, 1946; 5-ton Morris, 58ft. span, hand-operated; 5-ton Royce, 2-motor crab, 440/3/50; 5-ton King, 29ft. 3in. span, power hoist, hand travel; 5-ton Morris, 28ft. 6in. span, power hoist, hand travel; 4-ton Morris, 19ft. span, 220V, d.c. (3); 3-ton Adamson, 48ft. span, 400/3/50; 2-ton Adamson, 34ft. span, 400/3/50 (2); 2-ton Morris, 18ft. span; 2-ton Vaughan, 27ft. 6in. span, 2-motor; majority of the above are unused.
DERRICK CRANES.—7-ton Rushworth, hand, 30ft. jib; 5-ton Wilson, Electric, 70ft. jib; 5-ton Butters, hand, 45ft. jib; 1½-ton Anderson Grice, hand, 40ft. jib.
RAIL CRANES.—18-ton Brownhoist, steam, 50ft. jib; 10-ton Coles, steam, 40ft. jib; 10-ton Grafton, 34ft. jib, diesel conversion; 8-ton Wilson, steam, 35ft. jib; 5-ton Grafton, 35ft. jib, diesel conversion; 5-ton Smith, 50ft. jib (2); 5-ton Cowans Sheldon, 50ft. jib.
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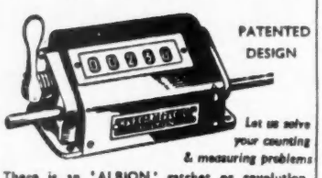

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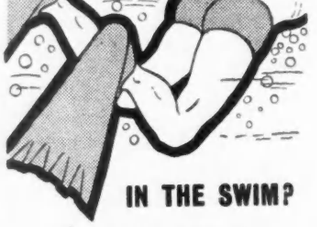

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The Lots are on View at Hartlebury on Wednesday, 16th September, 1959, between the hours of 9 a.m. and 4 p.m., and on the morning of the Sale Day between the hours of 8 a.m. and 11 a.m.

Admission only on production of Catalogue, which will admit two persons on the View Day and one person on the Sale Day. The Secretary of State for Air reserves the right to refuse admission. Catalogues, price ONE SHILLING EACH (Postal Orders, NOT Stamps), can be obtained from the Auctioneers :—
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E R

By order of the MINISTER OF WORKS Messrs.

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E R

By Order of the Minister of Supply

GOVERNMENT SURPLUS STORES

SALES BY AUCTION

		Main Location	*Auctioneers*
September 15-16	Machine tools and miscellaneous stores.	M.O.S. Storage Depot, **Ruddington, Notts.**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 54272.)
September 24	Machine tools and miscellaneous stores.	M.O.S. Storage Depot, **Rotherwas, Hereford.**	**RUSSELL, BALDWIN & BRIGHT, LTD.** (Dept. L), 20, King Street, Hereford. (Tel.: 4366.)
September 29-30	Machine tools and miscellaneous stores, including :	M.O.S. Storage Depot, **Byley, Nr. Middleswich Cheshire.** (Sale at Cheetham Town Hall, Cheetham, **Manchester, 8.**)	**J. H. NORRIS & SON** (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)
	lathes ; horizontal millers ; automatics ; grinders ; radial drill ; pedestal and bench drills ; presses ; punching and shearing machines ; grinders and polishers ; rotary furnaces ; electrical and radio equipment ; generators ; battery chargers ; cable ; M.T. spares ; tyres and tubes ; petrol trucks ; radar cabins ; electric hoists ; electric motors ; roller conveyor ; periscopes ; telescopes ; binoculars ; watches ; pipes and pipe fittings ; steel lockers ; office and other furniture ; nuts ; bolts ; screws ; washers ; greatcoats ; pullovers ; footwear ; scrap canvas ; blankets ; webbing ; bandoliers, &c.		
October 2	**Miscellaneous stores.**	Returned Stores Group, Reed Hall, Colchester, **Essex.**	**FENN, WRIGHT & CO.** (Dept. L), 146, High Street, Colchester, Essex. (Tel.: 3171.)
October 7	**Vehicles and miscellaneous stores.**	Central Ordnance Depot, **Bicester, Oxon.**	**MIDLAND MARTS, LTD.** (Dept. L), Market Square, Bicester, Oxon. (Tel.: 73.)
October 14	**Miscellaneous stores.**	Northern Command Ordance Sub Depot, **Barlow, Nr. Selby, Yorks.**	**BARTLE & SON** (Dept. L), 50-52, Merrion Street Leeds, 2. (Tel.: 2.0898.)

Applications for catalogues, available 14 days prior to date of sale, should be made *only* to the auctioneers shown above (price of catalogue 1s. 0d.—P.O. only).

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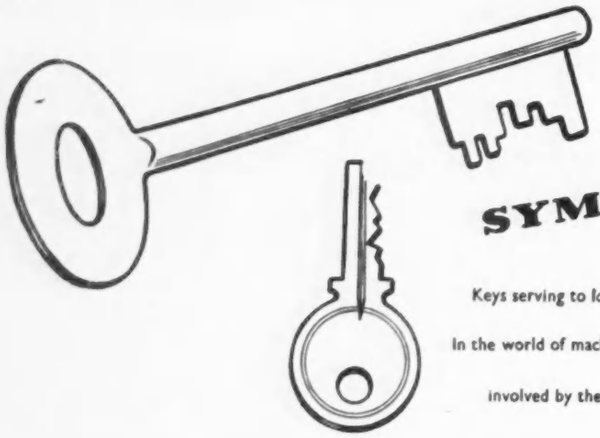

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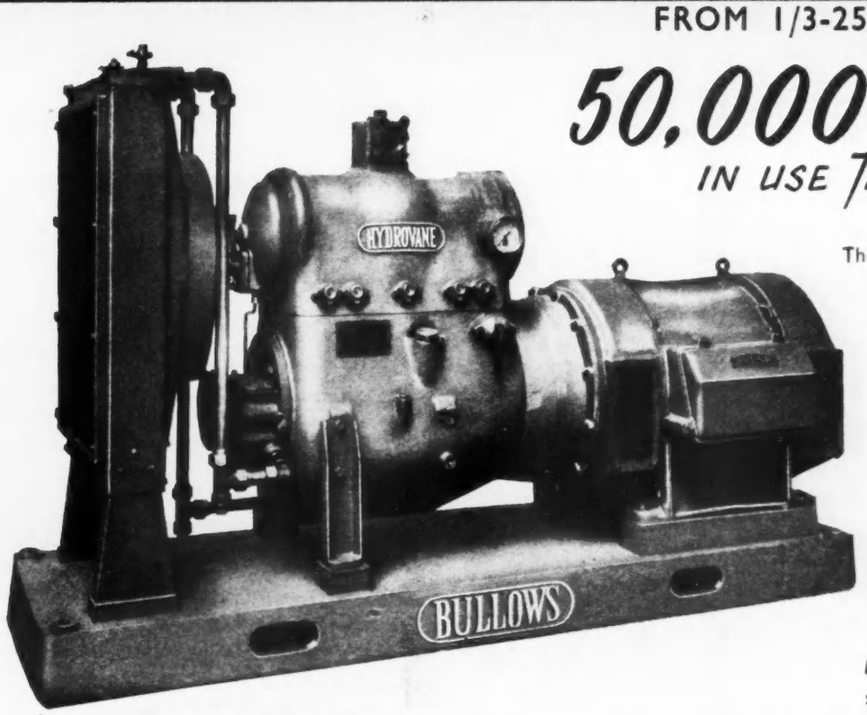

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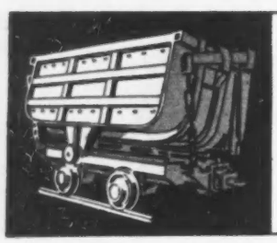

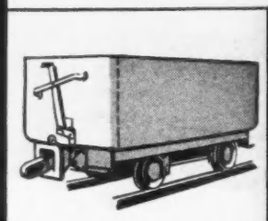

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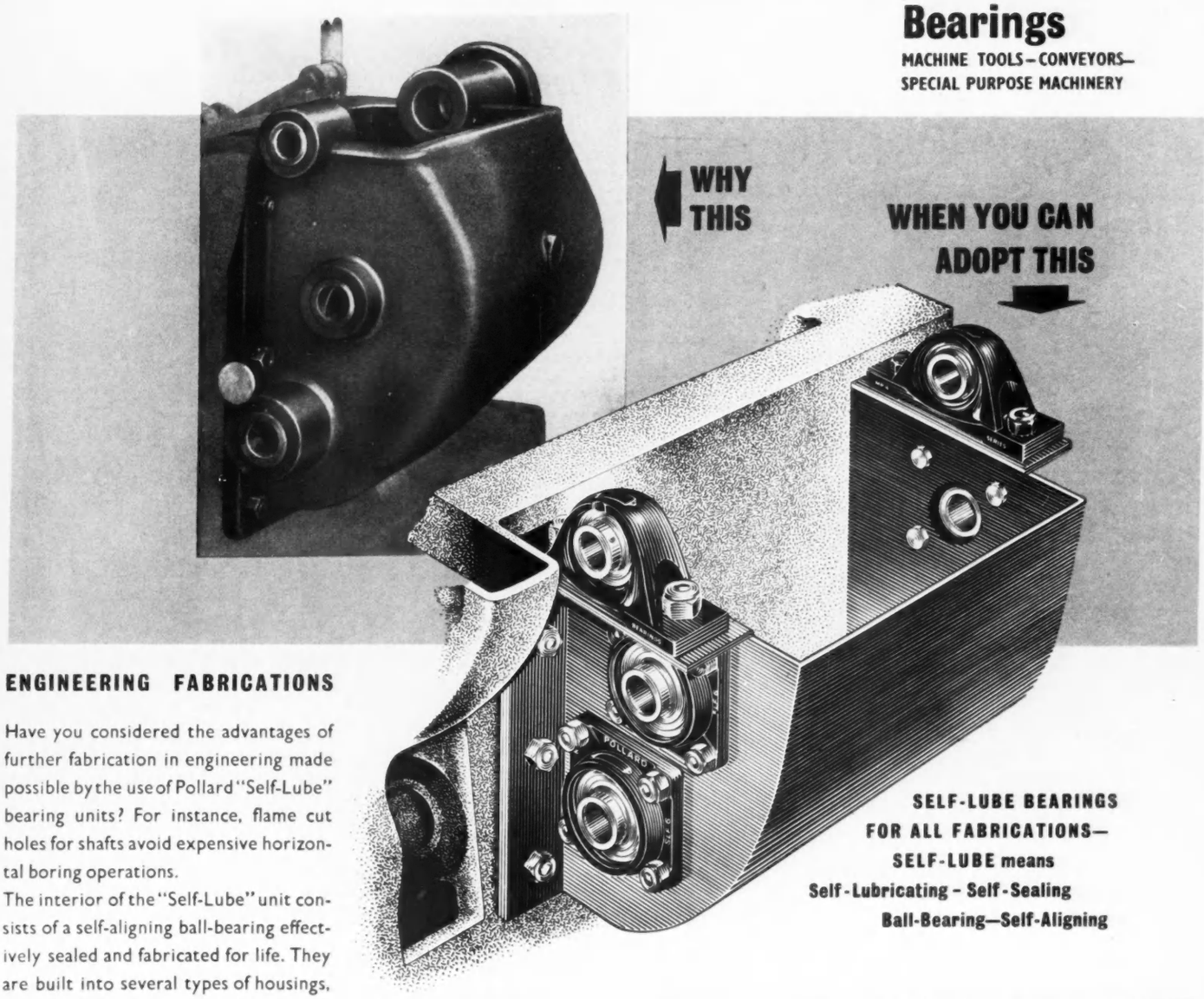

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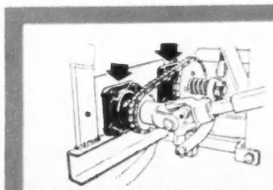
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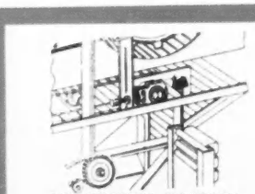
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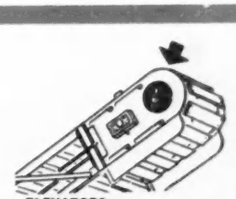
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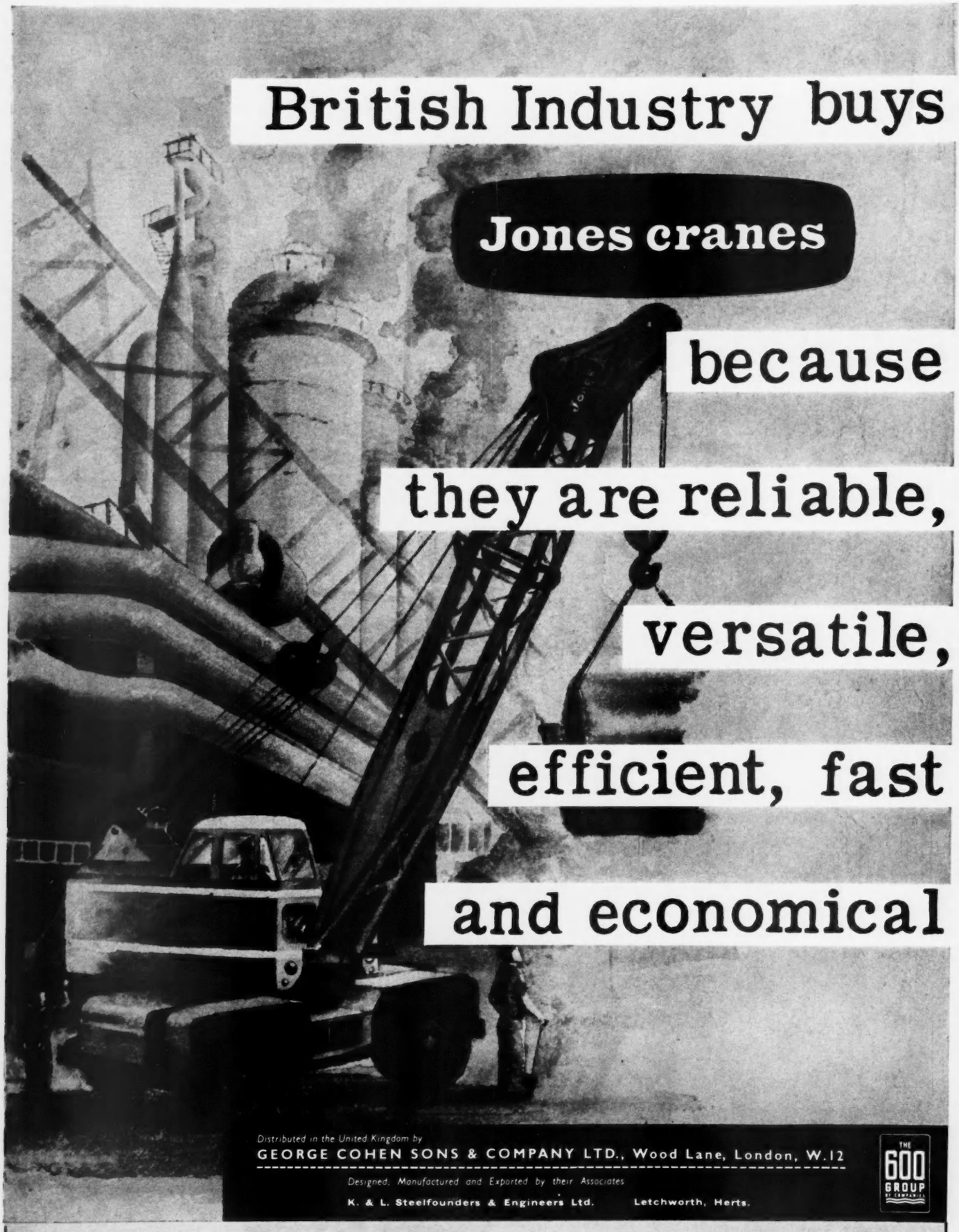
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